NATIONAL IRRIGATION,

&c. &c.

From the Author

NATIONAL IRRIGATION,

To W. Chap

OR THE

VARIOUS METHODS OF

WATERING MEADOWS;

AFFORDING

MEANS TO INCREASE THE POPULATION, WEALTH, AND REVENUE OF THE KINGDOM,

BY AN

AGRICULTURAL, COMMERCIAL, AND GENERAL ECONOMY IN THE USE OF WATER.

By WILLIAM TATHAM,

AUTHOR OF THE POLITICAL ECONOMY OF INLAND NAVIGATION, AN HISTORICAL ESSAY ON THE CULTURE AND COMMERCE OF TOBACCO, COMMUNICATIONS CONCERNING THE AGRICULTURE AND COMMERCE OF AMERICA, &c.

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DEDICATION.

TO SIR JOHN SINCLAIR,

BARONET OF ULBSTER, &c. FIRST AND
LATE PRESIDENT OF THE BOARD
OF AGRICULTURE, &c. &c.

SIR,

THE preſſures of a war, to the merits whereof I am unfortunately blind on all ſides, have compelled me to capitulate with cuſtom, which impoſes the condition of a dedication; and to this you politely aſſent, becauſe I am perſuaded that it may gratify many when they are appriſed that you

b have

have ſeen and approved the eſſential parts of my book.

I truſt poſterity will conſider this conceſſion, from both of us, an *honorable ſurrender*: they will at leaſt learn, that we have devoted our thoughts to pacific improvements in the midſt of ſtrife and tumult; and they will perhaps credit that I am neither vain enough to ſuppoſe you will derive honor from any dedication of mine, or weak enough to believe you think ſo.

The true end of this addreſs then will be to advertiſe ſociety that we mutually agree concerning the ſubſtance of the following ſheets. It is a ſolid repaſt which alone ſuits the palate of a Briton; and I leave the flummery of adulation to thoſe who think ſo faſhionable a deſert

might

might indulge the appetite of a captious critic.

I pray to God to proſper your zeal in the cares of agriculture and humanity, and have the honor to be,

Sir,

Your obedient

Humble Servant,

WM. TATHAM.

INTRODUCTION.

EVERY man who has been concerned in the publication of a book is apprifed, that the printing of the beginning of the work is the laft office of the Printer, though it is not always fo with the Author.

The writer, however, who has time and experience on his fide, may fometimes on this account have a better opportunity of correcting himfelf in the cafe of an overfight; of apologizing for thofe inadvertencies which are wont to befet the ftudious man; and of apprifing his readers more fully of the tendency of his defign.

The language in which mine is communicated is a matter of fuch little importance, fo that it be but intelligible, that I fhall make no apology for the defects of

erudition:

erudition: it ſatisfies me that liberal minds will diſtinguiſh the kernel from the ſhell.

In deviſing a plan for the nation to profit by, I have thought it proper to review the ſcience which I have ventured to recommend an attention to; and to trace, as far as they have occurred to me, the practical examples whereby individuals may reap inſtruction and wealth. Zealous to promote theſe uſeful ends I have been leſs ſolicitous about the eclat of the means I have uſed; and there will, probably, be found inaccuracies of ſtyle and compoſition which I do not profeſs to judge of. I perceive alſo ſome little degree of overſight in my recitals, which I feel incompetent to correct according to the tide of criticiſm: I can only ſay, that I have endeavoured to give Cæſar the things which belong to him, and to render to ſociety all thoſe duties I feel impreſſed with.

In the courſe of my readings I have ſelected ſpecimens of irrigation from various countries; and I have endeavoured to arrange them in a kind of collective order, ſo that the ſeveral methods, the means and the reſults may afford ſtimulus and practical in-

ſtruction

ſtruction from more than the reſources of theory. I cannot but lament that the ſtate of the times prohibits the expence of illuſtrating, in this firſt eſſay, all the varieties of machinery which might well apply on plates.

The ſubject of warping, though ſomewhat new and local, will be found worthy obſervation; and I flatter myſelf that this little book will prove the means of introducing it into many countries where it has never been heard of, and of ſtimulating the practice of flooding on ſuch rivers as the Miſſiſippi, where the richeſt particles of the ſoil have too long been permitted to waſte with the unheeded decreaſe of inundations, naturally favourable to agriculture.

The irrigations of the Nile, of Spain, and of France, afford many examples which deſerve the notice of the nation and of the practical farmer; while the Engliſh Counties, on the other hand, remunerate leſſons to thoſe who have taught them. None of them are without ſome peculiar point of inſtruction: Lincolnſhire affords examples for low and ſunken grounds; Glouceſter and Wiltſhire, a complete ſyſtem for level meadows in ordinary; Cheſhire, a ſingular method

thod of procraſtinating water on hilly lands; and Devonſhire combines the watering of meadows with the means of conveying its produce.

I have paid but little attention to the head of objections againſt irrigation, becauſe all which have occurred to me ſeem to be ſo futile as to need no extraordinary arguments to ſurmount them; and the reſults which are exhibited bear an unanimous teſtimony in their favour.

The irrigation of Aberdeenſhire has furniſhed a new diſcovery of no ſmall importance: it has proved to us that heath may be changed into graſs by the mere act of ſimple irrigation; and it leads to a mode of levelling which deſerves the national care. It does more than this, it introduces us to the knowledge of an author, who, in my opinion, has done more for the cauſe of humanity than the victories of Egypt; and whoſe whole life and works are replete with benevolence and productive intelligence.

In regard to machinery for the purpoſes of irrigation, it ſhould chiefly be ſuch as the ſmall farmer may command. Simplicity and cheapneſs are the points of advantage which enables him to water more land by a

few feet elevation of his fluid; and the community will partake the benefit of this medium of accumulated ſtores. It behoves the public, however, to ſeek more powerful means to ſupport a general ſyſtem; and it ſhould be remembered that public penuriouſneſs ends frequently in private fleecing. It is otherwiſe with the individual for whoſe uſe I have recited machines and methods.

The incloſure of waſte lands, and the culture of timber, appear to me to be among the firſt conſiderations of Britiſh improvement; and I ſubmit to the reader the manner in which I have connected them with the ſcience of irrigation. I have endeavoured to give an ample example of the capacity of canals in my plan for extending them through the mountains of my native country; and I have only to lament that I can neither attach the power of my anceſtors to my inclination to improve them, or perhaps rouſe my relations, who poſſeſs many of them, to ſee the amelioration which they are capable of receiving. If, however, a more thinking part of ſociety ſhould ſee the ſtate of things with my eyes, and ſhould prove the ſolidity of my theory by practice; there will remain no difficulty as to the reſidue

ſidue of the kingdom: for every body muſt be ſatisfied, that a ſyſtem which ſubdues the moſt ſtubborn heaths and hills, will be competent to extend itſelf into every part of the iſland.

On the ſubject of artificial ſprings I could never enforce too much; but it will poſſibly be more efficient if I leave the reader to his own reflection, and an inſpection of the apparatus.

In the ſubſequent part of my book, I truſt the ſtateſman will find himſelf ſtill more intereſted: it cannot be a matter of indifference to him that there is a great extent of territory which may be irrigated; that the landed income is capable of increaſe; that the value of irrigation can be aſcertained by experience; that the nation poſſeſſes both reſources and ways and means; or that my plan for national improvement can be employed to increaſe the revenue by enriching the individual.

So far as the people of this great metropolis are concerned, I preſume it intereſts them to conquer villainy and fire; and on theſe points I refer them to my plan for the management of criminals, and the example

for

for watering houſes, which I have applied to Bedford Square.

Ultimately, I requeſt a notice of my hints towards laying the duſt of roads; this ſubject merits, and has capacity for, more inveſtigation than I have time to give it: and, though it is certainly a luxury worth regarding that we can travel without raiſing the duſt, it is ſtill more important to the health and ſtrength of the noble animal who conveys us, and more ſo to the pocket which muſt pay for the too thoughtleſs deſtruction of him.

It remains as a conſolation, let what may be the fate of my book, that the Board of Agriculture ſeem to correſpond with me in opinion of the ſubject, as their circular letter will atteſt.

In ſubmitting my writings to the public peruſal, I have only to wiſh that they may reap from them as unlimited profit, as tracing theſe ſubjects has given ſatisfaction to

January 18,
1801.

THE AUTHOR.

CON-

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Mr.

Horticultural

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MEANS

TO INCREASE THE POPULATION, WEALTH, AND REVENUE OF THE KINGDOM, BY VARIOUS METHODS OF WATERING MEADOWS; AND BY AN AGRICULTURAL, COMMERCIAL, AND GENERAL ECONOMY IN THE USE OF WATER.

PRELIMINARY REMARKS.

THERE are three leading principles particularly appropriate to the Kingdom of England, which generate confidence abroad, and afford apparent ſecurity to its territorial poſſeſſions at home, under the diſtinctions of *meum* and *tuum*:—theſe are, the ſtability of its legal maxims; the ſtrict integrity of its commercial engagements; and its long-tried inacceſſibility to a foreign enemy.

Such a baſis as this may enable government to obtain a credit, both at home and abroad, upon all its rational anticipations of *future* eligible profit upon *preſent* undertakings of internal improvements, that are founded upon ſound data.

 Recurrence

Recurrence to paſt events will afford an eaſy-diſcovered example, in numerous inſtances, of royal bounties, containing immenſe capacities, from whence public agents find it difficult to gather aid in the time of need, through the unpopular medium of *taxation:* yet poſſibly in many inſtances the individual proprietor is found wholly inattentive to a *paſſive* ſubject matter, which remains uncultivated in his hands; and thus withholds its proportionate ratio of public resources, for want of an application of the active means of production.

This experience ſeems to urge the propriety of GOVERNMENT ITSELF UNDERTAKING extenſive operations, to render its *own* means productive, in preference to laviſhing them upon men of inactive diſpoſitions; becauſe they will find it eaſier to exerciſe a will over that which they actually poſſeſs, than to ſupport the expence of public operations by reclaiming ever ſo juſt and reaſonable a remuneration from individuals, in a way which neceſſarily encounters as great a variety of opinions, diſpoſitions, and ſelf-conceited intereſts, as it may chance to meet with different faces and complexions.

I perceive a very conſiderable miſtake in ſome

ſome foreign countries with reſpect to the true *national circumſtances of Great Britain*. The kingdom is believed to be in the higheſt poſſible ſtate of culture and manufactures, and overflowing with population. It is a ſtriking proof of this opinion, that even the Americans, who are ſcions of the ſame root, have built moſt of their late popular misfortunes upon the ſandy bottom of this glaring error. I call it *a glaring error*, becauſe I do not think it requires any abundant penetration to diſcover that Great Britain, under all thoſe advantages of climate and population which have been aſcribed to her, is by no means a perfectly cultivated country; or even within a thouſand years of her zenith in agriculture or manufactures.—A period which, I truſt, will be found ſufficient for *our* occaſions, and for an honourable redemption of the *public debt*.

But probably ſhe may prove in a condition to effect this object in a tenth part of that time, by the *civil* employment of *all* her people even, *partus ſequitur ventrem*, in a way which may afford preſent reſources from proſpects of production in futuro, that may juſtify ſpeculations which will re-

turn fortunes to our grandchildren with certainty.

The eſtabliſhment of a Board of Agriculture has, perhaps, been one of the wiſeſt theoretic meaſures that a nation ever adopted; and from the proſpects of practice, we are not only led to expect the enrichment of the country through the productive ſtimulus of individual competition, but while men of active and liberal minds continue in office, and cheriſh rational deſigns with the means of experiment and execution, we ſhall obtain indubitable proofs of exiſting capacities for an actual improvement of the public reſources; and a new field is laid open for the encouragement of individuals in works of national enterpriſe, through a teſtimony of truths which ſtare the foes of harmony out of countenance, and offer *ſound* materials for a truly politic ſuperſtructure.

We learn from the agricultural views of the ſeveral counties, which have been wiſely collected to a focal point, under patronage of the Board, that in many of them huſbandry has been much neglected, lands remain yet in a ſtate of nature, and the hand of art has but availed itſelf partially of elementary bleſſings.

But

But of all the inſtances of agricultural, houſehold, and commercial economy, which call for the attention of philoſophical obſervation and ſcientific aſſiſtance, none appears to be more conſpicuous than the neglect of an *economical uſe of water.*

Indeed, improvements in reſpect to the various applications of this element, which might be contrived for our better accommodation, ſeem to be loſt ſight of, like moſt other providential bounties, in an imaginary idea of the ſuperabundant infinity of the natural ſupply; and an habitual indifference beyond the ordinary purpoſes which have accompanied cuſtom from early periods of untutored nature.

I have often attempted, in vain, to impreſs men, to whom fortune had been favorable, with certain ideas which I conceived to be intereſting to themſelves and to mankind; and have frequently been rebuffed on the ground of *my original projects* with queſtions whether I had been on the ſpot? or if I had ever ſeen the like carried into execution heretofore? as if ſcientific improvement exiſted without an origin; as if every new place muſt need a new philoſophical principle: or the generous public ſpirit

ANTIENT EXAMPLES OF IRRIGATION.

Let us, however, in the firſt place recur back to the ancients, and explore the regions of early-improved countries; of Greece, of Rome, of Egypt, and of China.

In Beotia it is ſaid that immenſe works antiquity, not now to be traced, have been conſtructed to *drain off*, or to prevent the overflowing of the waters of Lake Copaïs (according to the Abbe Barthelemi); and that theſe are diſtributed in various canals over the whole breadth of the mountain.

There ſeems to be little doubt that theſe aſtoniſhing works were for the purpoſe of *agricultural irrigation;* for if they had been contrived, as the Abbe conceives, to prevent the overflowing of the Lake, pray why did not that Lake drown the country before theſe canals were made? How would it have been poſſible to get at premiſes ſo drowned in the mountain to improve them? Or is there any other probable purpoſe for

* See Phillips's Navigation, p. 2, cited from Anarcharſis.

which

which they could have been conſtructed, but the intereſting purſuit to which I have attributed their deſign?

* Magnificent aqueducts are ſaid to have been conſtructed at Rome at a vaſt expence, for ſupplying that populous city with water. Theſe are reputed to have been variouſly formed, both in reſpect to conſtruction and material; ſome paſſing under ground, ſome above ground, ſome extending a hundred miles, aud built of ſtone, brick, and wood, as occaſion ſerved. Nine of theſe aqueducts are recorded to have diſtributed their contents through thirteen thouſand five hundred and ninety-four pipes, of one inch diameter, perhaps to culinary uſes in part, but greatly to irrigating of gardens and other grounds, as the remains of baſins and fountains ſeem to indicate: nor is it probable, in ſo high a ſtate of ſplendor as Rome enjoyed, that theſe advantages could have eſcaped their notice.

† The works conſtructed by the antient ſovereigns of Egypt for diſtributing the waters of the Nile, ſays Adam Smith, were famous in antiquity; and the ruined remains

* See Phillips's Navigation, p. 3.

† Smith's W. of Nations, Vol. III. p. 33.

of

of ſome of them are ſtill the admiration of travellers. Thoſe of the ſame kind which were conſtructed by the antient ſovereigns of Hindoſtan, for the proper diſtribution of the waters of the Ganges, as well as of many other rivers, though they have been leſs celebrated, ſeem to have been equally great. Both countries accordingly, though ſubject occaſionally to dearth, have been famous for their great fertility: though both were extremely populous, yet, in years of *moderate* plenty, they were both able to export great quantities of grain to their neighbours.

Egypt ſeems to have profited more than any country, not even excepting China, by the fertilizing advantages of irrigation which the overflowings of the Nile afforded, and which were converted to the greateſt profit by the care of its antient governments.

The beauty of the canal of *Faoua*, as deſcribed, from *Abulfeda*, by Phillips *, is peculiarly deſcriptive of the benefits of irrigation: "No proſpect can be more enchanting or agreeable. Gardens, groves, and eternal verdure adorn its banks, which are ſhaded by date trees, covered with vines, and em-

* Phil. Naviga. p. 5.

bclliſhed

bellifhed with pleafure houfes." This canal is faid to have been cut from the Nile to Alexandria by Ptolemy, to fill the immenfe cifterns, which are vaulted with great art, and conftructed in all parts of that city. The numerous magnificent aqueducts* are ftill almoft entire, although they are above two thoufand years old; but they are now ufelefs, as they have been for many ages.

Mr. Phillips gives the following account of the irrigations performed by the inundations of the Nile, on the authority of the Baron de Tot: "The annual inundation of the Nile is the fource of fertility to Egypt. When the waters have rifen to a certain height, the *khalig*, or grand canal, is opened, by which it is conveyed, by a prodigious number of fmaller canals, into refervoirs and cifterns, to be diftributed among the fields and gardens as it is wanted. To determine when it has attained to this height, a pillar, called a *Nilometer*, is erected in an ifland oppofite Cairo, and divided into *pics*, a meafure of about two feet. According to Baron de Tot, the progrefs of the inundation is obferved at the nilometer, fituated at the fouthern point of the ifland of Rhoda, op-

* Vide Phillips.

posite Old Cairo. Public criers, distributed in each quarter of the capital, every day make known to the people the rising of the waters, till they are come to the height proper for opening the canal; by which means they are conveyed to the middle of the city and the cisterns: but this moment cannot be ascertained with precision, because superstition prevents the eye of curiosity from approaching the graduated column placed in the centre of the basin of the nilometer. The cry of "*Oof-Allah,*" which signifies God has kept his promise, proclaims the opening of the canal. Children, bearing streamers of different colours, accompany the crier, and diffuse a general joy at the certainty of plenty."

It does not appear that the waters at other times suffice for the agricultural demand of the country; or that this is the mark of the *greatest* plenty. To produce that degree, the waters must reach the foot of the mountains, and then the criers proclaim, "*Minel Dgebel il Dgebel,*" from one mountain to another *.

It appears farther, that there are many

* Phil. Naviga. p. 6, &c.

other

other canals, which are merely under the care of thoſe who are particularly intereſted in their irrigations; and that the culture may be compared to a well-managed kitchen garden.

The lake of *Moeris* was conſidered as one of the moſt wonderful labours of the kings of Egypt; and certainly it was not more wonderful than uſeful.

Different authors, as Herodotus, Diodorus Siculus, Strabo, Pompilius Mela, and Pliny, are ſomewhat various in their accounts of its ſize; but all agree in the immenſity of its capacity and utility, which are the chief points we ſhould contemplate in the example, and which ſhould ſtimulate our exertion, with a bluſh to be ſo far behind ruder ages whom we occaſionally affect to pity.

King Moeris is ſaid to have conſtructed this grand reſervoir by art, with a view to regulate the irrigations of the Nile, as its inundations created a neceſſity. Two pyramids, each three hundred feet high, were erected in the middle of it, upon a proportionate baſe*. Doubtleſs this is an ample proof

* See Rollin's Ancient Hiſtory, Vol. I. p. 177, Glaſgow Edition, 1795.

proof of its being human workmanſhip; although the moſt creditable account makes it no leſs than ſeven or eight French leagues in circumference.

From this lake there is a canal of eighty five ſtadia, or four French leagues long, which communicates with the Nile by proper floodgates or ſluices; and the charge of ſuperintending theſe was eſtimated at fifty talents, or fifty thouſand French crowns, valued at eleven thouſand two hundred and fifty pounds ſterling*. Its fiſheries are reputed to have afforded an immenſe revenue; but there remains not a ſhadow of doubt, with me, that its powers of irrigation were both the leading motive to its conſtruction, and the ſuperior ſources of wealth with which it abounded: when the nileometer, for inſtance, indicated an overflow or dangerous inundation, the opening of the ſluices muſt have contributed to relieve its preſſure on its embankments; and, if a dearth enſued, it is equally certain that ſo large a body of water muſt have been important to vegetation.

Without entering into the various philoſophical reaſonings of the ſeveral authors

* See Rollin's Ancient Hiſtory, Vol. I. p. 178.

whom

whom I have cited, concerning the riſe and fall of the Nile, it will be deemed enough for thoſe who know the river Miſſiſippi, and can compare the two together, to aſcertain the actual ſtate of its annual inundations. Although travellers differ indeed in ſome degree with reſpect to the period of its riſe and fall, it ſeems tolerably certain that the rains fall in April in Abyſſinia, and that the Nile riſes ſlowly about the month of May: this correſponds pretty much with thoſe ſpring floods of the Miſſiſippi, which may be chiefly aſcribed to the diſſolution of the mountain ſnows.

The foregoing account of the nilometer, from the Baron de Tot, gives the quantum of inundation by a meaſure marked in pics of two feet each, on the column which is erected in the baſin of the nilometer, and which probably correſponds with the pyramids in *Lake Moeris*, which may have been erected there for a ſimilar purpoſe. The Baron has not favoured us with an accurate admeaſurement of the floods, on account (he ſays) of the interfering ſuperſtition; but we are enabled to draw a greater degree of certainty from ſome other hiſtorians. Pliny ſtates the juſt or beſt medium height

of

of the Nile at ſixteen cubits flood; each cubit being eighteen inches*. Twelve or thirteen cubits only are ſaid by this author to threaten a famine; and if the riſe exceeds ſixteen cubits, the fresh becomes dangerous. From hence we may learn the juſt proportions of the embankments which are demoliſhed, in that country of uniform level which conſtituted the premiſes of operation under the kings of Lower Egypt; and, if we may be permitted to leave oracles and ſuperſtition at a proper diſtance behind our ſenſes, we may readily conceive a principle of civil engineering, which is competent to dethrone the river-god of Egypt.

Moſt of theſe writers agree in one point ſomewhat eſſential to be underſtood; that is, that the riſe and fall of the Nile occupies a quarter of the year, in Egypt; but that this loſs of time is made amends for by its fecundating particles and the influence of the ſun. Yet, although the huſbandman of Memphis ſeems to have been releaſed by native fertility from any extreme labour of the plough, we find him vigilant in the duties of irrigation which were enjoined by the national

* Rollin, Vol. I. p. 182.

law,

law, and indicated every where by public indexes or water gages: nor were thofe who had to water more elevated fpots than the common furface unmindful of mechanical means, tho' very far fhort of the perfection of Englifh mechanics. Spiral pumps, ascribed to the inventive faculties of Archimedes, were applied to purpofes of irrigation, both by hand and moved by oxen; and the facred record, which has been quoted by Mr. Rollin*, feems to imply the ufe of *foot* machines, fimilar to thofe defcribed by Sir George Staunton in his travels in China.

We have here, however, a precedent for the public intervention in works of national irrigation; and are not lefs without fatisfactory proofs of the economical advantages which are made to flow from the paternal care of thofe thinking monarchs, who have the peace and happinefs of their people at heart. It is faid, that no country on earth poffeffes a more fruitful foil than that of the Nile; yet it is equally afcribed to its fyftem of irrigation. Numberlefs canals were cut in all directions, to facilitate the overflowing of the lands. The numerous villages which

* Deuteronomy, xi. 10, 13.

ſtood on the banks of the river, had each their canals, which were ſyſtematically opened to let the water into their country. Villages farther at a diſtance had ſimilar conduits, in ſucceſſion, to the extreme of the kingdom; and the waters were conveyed, progreſſively, to places the moſt remote.

Perſons were not permitted to cut trenches to receive the waters till the river was at ſuch a height; nor to open their trenches altogether. They began with opening them in Upper, and afterwards in Lower Egypt, according to rules that were preſcribed in a roll or book, in which all the *gages*, or meaſures were ſet down. By this method the water was diſtributed with ſuch care and economy that it ſpread itſelf over the whole ſurface of the country; and it has been ſaid, of the rains which fall in the upper country, not a tenth part reaches the ſea.

It is ſaid, that at two ſeaſons of the year Egypt exhibits a proſpect, which is yet unrivalled on the face of the earth*; how far the Miſſiſippi may in future vie with it, is a point yet undetermined. If a man aſcends a mountain, or one of the Pyramids, in

* See Rollin, Vol. I. p. 187. Seneca Nat. Queſt. L. iv.

July

July or Auguſt, he beholds a vaſt ſea, in which numberleſs towns and villages appear, with ſeveral cauſeways leading from place to place; the whole interſperſed with groves and fruit-trees, whoſe tops are only viſible; and the ſcope is bounded by mountains and woods at the moſt diſtant view which the eye can diſcover.

On the contrary, in the months of January and February, when winter elſewhere prevails, the whole ſpace is a vaſt expanſe of beautiful meadows, beſpangled with flowers, and enlivened by flocks and kine, and by numerous herdſmen and gardeners.

Is it not worthy of ſuch a country, that the peaſant ſhould hold an honourable name; and that thoſe ſervile occupations of the herdſman and farmer, which alone afford the means of diſſipation to higher ranks, ſhould have an honeſt pretenſion to the public eſteem?

"It will be always ſo with every kingdom, ſays Mr. Rollin*, whoſe governors direct all their actions to the public welfare. The culture of lands, and the breeding of cattle, will be an inexhauſtible fund of

* Rollin's Ancient Hiſtory, Vol. I. p. 220.

wealth in all countries, where, as in Egypt, theſe profitable callings are ſupported and encouraged by *maxims of ſtate policy*. And we may conſider it as a misfortune that they are at preſent fallen into ſo general a diſeſteem; though it is from them that the moſt elevated ranks, as we eſteem them, are furniſhed, not only with the neceſſaries, but even the delights of life."

Again, ſays the *Abbe Fleury*, in his work on the manners of the Iſraelites*, "It is the peaſant who feeds the citizen, the magiſtrate, the *gentleman*†, the eccleſiaſtic: and whatever artifice and craft may be uſed to convert money into commodities, and theſe back again into money; yet all muſt ultimately be owned to be received from the products of the earth, and the animals which it ſuſtains and nouriſhes. Nevertheleſs, when we compare men's different ſtations of life together, we give the loweſt place to the huſbandman: and, with many people, a wealthy citizen, enervated with ſloth, uſeleſs to the public, and void of all merit, has the preference; merely becauſe he has more

* Cited by Mr. Rollin, Vol. I. p. 220, 221.

† See Doctor Franklin's Tale of the Negro's Hog!

money,

money, and lives a more eaſy and delightful life."

"But let us imagine to ourſelves a country where ſo great a difference is not made between the ſeveral conditions; where the life of a nobleman is not made to conſiſt in idleneſs and doing nothing, but in a careful preſervation of his liberty, that is, in a due ſubjection to the laws and the conſtitution; by a man's ſubſiſting upon his eſtate without any dependance, and being contented to enjoy a little with liberty, rather than a great deal at the price of mean and baſe compliances—A country, where ſloth, effeminancy, and ignorance of things neceſſary for life, are held in their juſt contempt, and where pleaſure is leſs valued than health and bodily ſtrength—In ſuch a country it will be much more for a man's reputation to plough, and keep flocks, than to waſte all his hours in ſauntering from place to place, in gaming, and expenſive diverſions."

* La Compte ſays, that although China was not of itſelf a fruitful country, its canals would make it ſo. "One large canal," ſays he, "generally runs through every

* See Philips's Naviga. p. 11.

province; and a vaſt number of ſmaller ones are cut from that large one; which, again, are ſubdivided into ſtill ſmaller ones, or rather rivulets, that end at ſome village or great town. Sometimes they diſcharge themſelves into a lake, or large pond, from whence all the adjacent country is watered; ſo that theſe clear and plentiful ſtreams, embelliſhed by a great number of fine bridges; bounded by great and convenient banks, equally diſtributed through vaſt plains, covered with a numberleſs multitude of boats and barges, and crowned (if I may uſe the expreſſion) with a prodigious number of towns and cities, whoſe ditches they fill, and whoſe ſtreets they form, at once render that country the moſt fruitful and moſt beautiful in the world."

"* The Chineſe not only make canals for the convenience of travellers, but they alſo dig many others to catch the rain water which comes down from the mountains, and with which they water the fields in time of drought—more eſpecially in the northern provinces. During the whole of

* See Sir G. Staunton's Embaſſy, Vol. II. p. 473, 482, 499, 517, &c.

ſummer

ſummer you may ſee the country people buſied in raiſing this water into abundance of ſmall ditches or channels, which they cut acroſs the fields. In other places they contrive great reſervoirs of turf, the bottom of which is raiſed above the level of the ground about it, to ſerve them in caſes of neceſſity: beſides, they have every where in the provinces of Xenſi and Xanſi, for want of rain, certain pits, from twenty to a hundred feet deep, from which they draw water with incredible labour. If by chance they meet with a ſpring of water, it is worth obſerving how carefully they huſband it: they ſuſtain it by banks in the higheſt places; they turn it here and there a hundred different ways, that all the country may reap the benefit of it; they divide it, by drawing it by degrees as every one hath occaſion for it; *in ſo much, that a ſmall rivulet, well managed, ſometimes diſpenſes fertility to a whole province**."

It is needleſs to dwell longer on examples of ancient irrigations, or their infinite productions. The memoirs of Major Rennel, the works of Duhalde, Lé Comte, Sir George

* Philips's Naviga. p. 14.

Staunton, and others, give numerous examples on the Ganges, Burrampooter, &c.; and many inſtances of importance are recited in my firſt volume of the Political Economy of Inland Navigation, Irrigation, and Drainage, &c.

IRRIGATIONS IN SPAIN.

In many parts of Europe there are inſtances of agricultural irrigation, highly worthy of Britiſh imitation.

In Spain, where ſome are wont to ſuppoſe men live in wretched indolence and poverty, becauſe they differ from themſelves in habits, we find examples of *induſtrious economy in the uſe of water.*

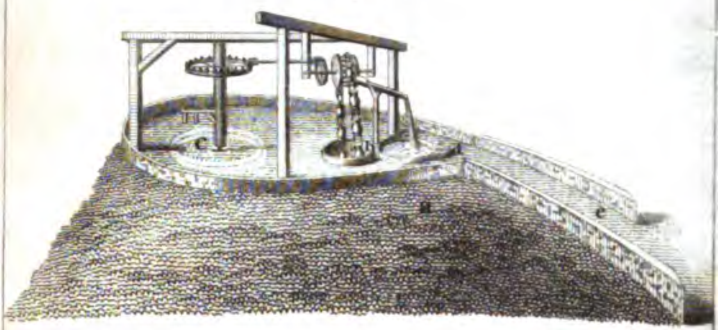
Many towns exhibit noble ſpecimens of ornament and uſe in this reſpect; and ſome have even venerable remains of yet perfect Roman aqueducts, aided by Mooriſh and modern repairs.

Almeida's, or public walks, planted with poplars, are to be found in moſt of the larger towns, and few of theſe are without fountains of pleaſure and of uſe; although many

The Noria of Spain.

To face page 25.

Fig. 1.



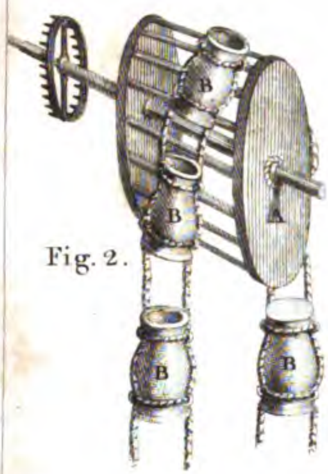


Fig. 2.

Fig. 3.
One of the Earthen Jars.

Fig. 1.

a. *The Mound of Earth.*
b. *The Noria-well.*
c. *Geer for the Cattle.*
d. *The Reservoir.*
e. *The Road up the Mound.*

Fig. 2.

A. *The Sproket Wheel.*
B. B. B. B. *Earthen Jars, which descend into the Well, by means of an endless Strap of Ropes.*

many of them are ſupplied by the application of animal labour to fill the reſervoirs, from whence ducts are diſtributed abroad to ſupply the calls of animal thirſt, and the abſorptions of irrigation.

Reſervoirs for irrigation are generally contrived, in Spain, upon what is termed the *Noria* plan.

The *Noria* conſiſts of a mound of earth, raiſed above the ſurface of the ground to a convenient degree of elevation, for conducting channels to the various parts of the ground which is intended to be irrigated.

This mound is walled round with brick or ſtone to keep it compact, or with earth and ſtraw rammed into a *caiſſon*, in the Mooriſh manner, ſimilar to the cheaper method of which the poorer *villages* are conſtructed: ſuch, for example, as the famous village of Puerta la Piche, where Don Quixote is ſaid to have received ſome of his honorary diſtinctions.

Upon this mound a reſervoir is elevated, together with a machine, worked by cattle, for the purpoſe of raiſing water to the reſervoir, from a well which is dug below it in the common way; or, where a convenient

cut

cut can be made to ſome adjacent river or ſtream, the water is conducted *through an arch*, opening a communication between the bottom of the *Noria-well* and ſuch convenient ſupply.

The method by which the water is then lifted is, ſimply, by an endleſs ſtrap; compoſed of two ropes paſſing over a ſproket wheel at the upper extremity, and hanging looſe into the water which is contained in the well below. Between theſe ropes a ſucceſſion of earthen jars are tied at proper diſtances, and are thus emptied at each and every revolution into a trough, which conveys the water into the reſervoir.

I think in the plains of La Mancha, near Manzanares, I counted about forty of theſe Norias at once in the cultivated grounds, which appear to be applied wholly to the purpoſes of irrigation: but as there is a grand canal, partly completed, within a ſmall diſtance of them, it is to be hoped the time is not far diſtant when theſe poor people will have much of this labour ſaved; and it is but juſtice to the king of Spain to ſay, that he ſeems far from being remiſs in a paternal care for his people, or a deſire to better

better their condition, ſo far as conſiderations of political ſafety may permit him to do it.

With regard to the mere ornamental improvements which are to be met with in his Catholic majeſty's gardens at his ſeveral palaces, and at the palaces of the biſhops, and convents of the clergy, (who have been ever mindful of good things in their way to Heaven) I ſhall leave them to the deſcription of a more fanciful pen, and content myſelf with obſerving a few particulars which admit of cheap and uſeful introduction into other countries, where I do not find them in practice, or where I think they may be improved upon to general advantage.

In the King's gardens at the palace of Sevilla, my attention was ſuddenly awakened by the ſound of a trumpet, which ſeemed to be low and rudely blown; and which I immediately perceived to be that held in the hand of the figure Fame, which juſt gave me timely notice to jump upon a bench out of the way of an artificial ſhower in reverſe, that proceeded from under my feet, and performed the three-fold office of irrigating and cleanſing the adjoining borders and walks.

The contrivance is thus conſtructed: an aqueduct, which receives the water from a

canal that collects its ſupply about ſix miles off, in the country, and is carried upon arches elevated upon pillars, forming a kind of colonnade, by the ſide of an old Roman way for about half a mile, from a corn mill to the city, paſſes cloſe by the palace; and ſupplies the baths "of the antient Queens," *(perhaps of the haram)* and the fountains in the gardens, which appear to have been repaired by the Moors, upon a foundation laid by the Romans, as is evidenced by ſeveral ſpecimens of antient ſculpture, both coloſſal and characteriſtic, which were dug out of the gardens, and are ſtill preſerved in the palace as his majeſty's property.

From this aqueduct there is a pipe which communicates into the wall of the adjacent fountain, which preſents a front at the head of the centre walk of the ſecond garden, that leads through evergreens to orange groves, to a labyrinth, ſeveral ornamental temples, &c.

The front of this fountain and ſome part of one ſide wall, which is beautifully covered with oranges as a wall fruit, are of a ruſtic groteſque conſtruction, with the water trickling through the artificial rock in imitation of nature. Upon the ſummit of this rui-

nated

nated wall ſtands the figure of Fame; and the chief fountain is ſo contrived, that when the water ſuddenly fills its pipes from the aqueduct behind it, the air is forced through the trumpet by hydroſtatic preſſure, and produces a ſound which diminiſhes gradually as the vacuum is filled.

This ſound is, I preſume, intended as the ſignal for playing off the fountains; which is alſo the ſignal for his majeſty's approach, if he deſigns to be preſent on public occaſions: and it is highly probable that the original invention kept pace with a period when Kings had little more to do than to laugh at their ſubjects for getting ſouſed; or hazard their lives as trifles in daily tournaments of pleaſure. But I think I have ſeen Charles IV. partake a wetting with his ſurrounding ſubjects for experimental purpoſes of more honor to his heart.

Among the numerous fountains in his Catholic majeſty's gardens at Aranjuez, I noticed one which is conſtructed upon a ſimilar principle with the above, and which calls my remembrance to its ſimplicity and utility. The principle of operation is the ſame with that of every other ſimple fountain, and depends upon the gravity of the head ſupply,

or

or preſſure of water: but what appears to me to be of moſt moment is, the contrivance of its ducts, which have a cheap and eaſy capacity for irrigation, and may, with very little additional expence, be applied to many other hydraulic purpoſes.

They conſiſt of leaden pipes paſſed from the reſervoir down each ſide of a flagged walk, and perforated at proper diſtances with gimblet holes, which penetrate through the wood they are caſed with into the hollow of the pipe. This circumſtance, regulated by the angle of elevation, enables a diſtribution of the water into every part of the walk by the turning of a cock, and might be advantageouſly uſed for the purpoſes of horticulture, agricultural irrigation, or diſtinct conduits for waſhing the ſtreets of populous cities, thus preſerving their harbours from the riſk of ſilting.

If ſuch pipes were laid along the ſides of the city road, leading from Paddington, through Pentonville, &c. I think a couple of turncocks would lay the duſt at much leſs charge than the hire of the carts which are employed in this ſervice, with ſuch opportunities of evaſion, that the boys who drive them are ſuffered to gull the public, and

laugh

laugh at them for being the dupes of a deceptive routine, wherein they ſtudy only to wet the middle of the road, for the ſport of duſting thoſe who walk the foot-paths, near the dirty-neglected edges.

In addition to the methods of irrigating in Spain, more or leſs of which is performed through aid of the fountain ducts in moſt inſtances, they ſeem to be attentive to the accommodation of animal thirſt, by the conſtruction of watering places by the way ſide; and ſome whereof, (particularly one which I obſerved in the dividing ridge between the waters of the Duero and Ebro rivers, not far from Brevieſca, in the province of Burgos) have conduits, of ſome miles in length, from a more elevated ſummit level.

IRRIGATION IN AMERICA.

I had written moſt of what I ſhall notice in reſpect to irrigation on the other ſide of the Atlantic ocean, before the ſecond volume of *Communications to the Board of Agriculture*, publiſhed this year, 1800, came before the public. It is, therefore, an after view of my manuſcript, which diſcovers to me how widely I have differed from the account of American irrigation, communicated by Mr. Strickland of York, whom I perſonally know, and perſonally eſteem. I premiſe this circumſtance, and ſhall alſo let my work ſtand as it is, leſt I ſhould be conceived to be influenced by a malevolent ſpirit in the contradictions I feel myſelf bound to maintain without retraction; both now, in the caſe of irrigation, and hereafter, in ſome other inſtances where a regard to truth and juſtice renders it my duty to volunteer it againſt thoſe who may have practiced impoſitions on Mr. Strickland, either through a want of information, or a deſire to gratify a ſplenetic prejudice, too circum-

circumfcribed, I fear, to extend its inquiries with liberal trouble.

I fhall make no other apology for this diffentient, than one which *reafon* will, I doubt not, admit: *a difinterefted perfon, born in England, and having thirty years perfonal acquaintance with the premifes and people which are fpoken of; and one who has been twenty-five years in public life there, and fo long acquainted with the extreme frontier of the back parts, will be as likely to know the facts which concern it, as the cafual informant of Mr. Strickland's tour.*

It will be obferved, however, that Mr. Strickland's perfonal obfervations on American irrigation apply chiefly to a part of America which I have not explored; and as the frontiers of the Southern ftates are, perhaps, not within his journal, it may be of fome importance to the prefent harmonic difpofition of the two countries, that, together, we may be able to render the communication more expanfive.

* Mr. Strickland tells us (*as far as he could learn*)

* *The Agricultural Report of Mr. Strickland's own county, York, claims the originality in that county, within fifty years back.*

learn) "Irrigation is known only in two parts of the United States, and in neither of them practiced to any confiderable extent. It offers no material circumftances worthy of imitation, nor is it conducted on any principles that are not at this time much better underftood in this country," meaning *England*. "*Connecticut* is the moft Northern ftate where it is met with: the practice was probably* *carried thither* by the firft fettlers, moft of whom emigrated from the counties in the Weft of England, where it is now beft underftood; but they do not appear to have kept pace in improvement with their kindred on this fide of the Atlantic.

The German tract in Penfylvania is the other part where it is practifed, and the knowledge was carried thither from Flanders or Germany. Two crops of hay are always cut where lands are thus artificially watered.

The law has ordained the right of the water to be in him who poffeffes the fpring head, or the higheft part of the ftream; he may confume what quantity he pleafes, but

* Communications to the Board of Agriculture, Vol. III. p. 165.

muft

muſt convey the remainder into the antient channel; he muſt not divert the ſtream or waſte the water to the prejudice of thoſe below him. The mode of applying the water is different in the two ſtates: in Connecticut it is turned on the land as ſoon as the weather begins to be warm in the ſpring; but it is not allowed to flow for more than twenty-four hours at a time: it is then taken off for a few days, then turned on again for twenty-four hours; and ſo on, till the meadow is nearly fit for cutting: immediately after which, it is applied again in like manner for a ſecond crop, and then again to force the after graſs in autumn; but it is always found to have the greateſt effect upon the ſpring crop.

In this ſtate they alſo apply water to their lands in another very different unuſual manner: they flood great tracts of low meadows, ſituated on running waters, juſt before the winter ſets in, to the depth of two or three feet, by ſtopping the courſe of the ſtream, and let them thus remain covered till the ſpring, *in order to keep them warm, and defend them from the froſts.* Theſe lands produce the following year a conſiderable quantity of coarſe hay, which, in conſe-

quence of the fine climate in ſummer, being very well got, is eagerly conſumed by the cattle in winter: after the hay is cut, theſe fields for the remainder of the year are paſtures.

In Penſylvania the water is uſually turned on the meadows about the middle of April, and is allowed to flow about two months; a few days after which, the ground having got dry, the crop is cut: as ſoon as the crop is off, the water is again turned on for three or four weeks, or till the land gets a ſufficient covering to defend itſelf from the ſun, at that ſeaſon very powerful: a ſecond crop is then ſoon ready for the ſcythe; after which the water is allowed again to flow over it, till within a ſhort time before it is wanted for paſturage, when it is turned off, in order that the ground may ſo harden, as not to receive injury from the treading of cattle. Which of the two methods of applying the water may be moſt productive, I know not, not having ſeen the meadows of Connecticut in the ſummer ſeaſon; but thoſe of Penſylvania bear abundant crops.

Water iſſuing from lime-ſtone in Penſylvania is thought preferable to any other running ſtream; but the warm, half-putrid

water from a reſervoir made for this purpoſe, which is not unfrequent, or a mill dam, in which it becomes ſoft, ſlimy, and muddy, is greatly preferred to all others; water of this kind, at this ſeaſon of the year, will in Penſylvania be heated as high as 85° by Fahrenheit's thermometer, and muſt have a great effect in forcing vegetation.

No art is uſed beyond a channel, carried on a level, as far as it can be done conveniently, over one ſide of which it can flow: no means have been taken for raiſing it above its natural level, which in many places might be performed with much facility.

Since the introduction of clover, theſe meadows are falling faſt into diſuſe, many of them having been already ploughed up, and converted into tillage: no farther improvements are therefore hereafter to be looked for in this branch of rural economy."

So far Mr. Strickland's account of American Irrigation extends. I ſhall only here remark, that a longer ſtay in the country, and a more minute inveſtigation, would have diſcovered to him, in the Southern and Weſtern ſtates, a few ſolitary examples, at leaſt, of improvements in irrigation, for which

D 3 the

the people of thoſe countries are no ways indebted to the tranſplanted genius of South Britain. In South Carolina and Georgia, the rice plantations form an immenſe irrigation: he might have found watered meadows of tolerable luxuriance in the fork of Broad River and Saluda, commonly called the Dutch Fork. In North Carolina, at the Mornavian towns, at Ramſour's mills, and in many other places, he might have found both common level, and lifted irrigations, performed by cheap and ſimple wheels; and in travelling the main road into the Tennaſſee country, he could not have avoided ſeeing the very wheel which would accommodate the wiſhes of the Board of Agriculture: future travellers will find this at Stover town, and many places throughout the back ſettlements of Virginia; and the practice of irrigation will be found in the counties of Berkley, Frederick, Shannandoah, Rockbridge, Bottetourt, Montgomery, Wythe, Waſhington, and the Tennaſſee counties; reaching from Potomack to the borders of Georgia.

I proceed to the account I had given heretofore without alteration; and if Gentlemen, who may hereafter ſeek for irrigation in the Weſtern ſtates of America, will remember to look

look for it on Reed creek in Wythe county, or at Captain Craig's, near the town of Abingdon, they will find a lifting wheel worth their imitation, in regard to cheapneſs and performance.

In the interior parts of America, the Germans and their deſcendants are particularly attentive to economy in the uſe of water; and when a Dutchman penetrates into thoſe countries to ſeek a domain eſtabliſhment for his family, a good mill ſeat and a ſtill ſeat are its two primary recommendations: next to theſe he eſtimates the meadow ground; and if nature affords him a water-fall of nine inches perpendicular height, he contrives to elevate it to as many feet, and diſtributes it round the higher trenches of his meadow, and to culinary purpoſes, by the help of a ſimple invention, which he terms his lifting wheel.

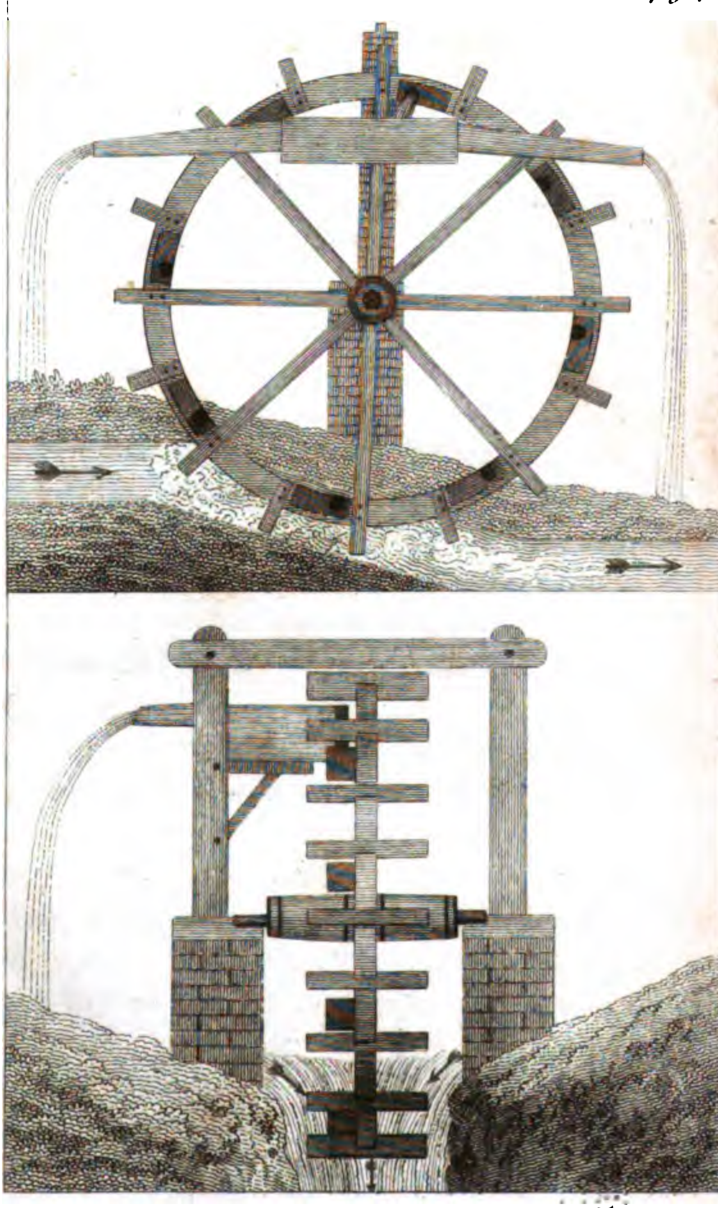
A lifting wheel is uſually conſtructed of common deal, oak, or any other boards nailed together in the readieſt way which occurs, to approximate ſuch material as you may happen to have, to the ſhape of a circle, whoſe diameter is equal to the perpendicular height of the ſummit level to which you would raiſe your water at a ſingle operation;

allowing for ſo much thereof as ſhould dip into the ſtream to fill your buckets, and ſo much as ſhould paſs above the uppermoſt trough to diſcharge the water from them.

This ſhape is then reduced to an exact circle by the means of a line and chalk extended from its centre, and the ſurplus plank being hewn down to the ſcribe of the circle, an axis of about two feet ſix inches in length is fitted to it with arms of the ſame plank, and two ſmall iron gudgeons to turn upon. Flutter boards are then fitted on with the ſaw, and cleated at convenient diſtances; with a cloſe box between every ſecond and third of them, nailed upon the rim of the wheel. Theſe boxes (by ſome termed gaining and looſing buckets) have two apertures or holes for receiving and diſcharging the water; and as the bucket is immerſed in the ſtream below, by the power of this little rapid acting upon the ſucceſſive flutter boards, the water is taken in at one hole, and diſcharged out of the other, as the wheel revolves it over the trough above. Theſe are ſometimes formed out of a worn-out cart wheel fixed upon an axis, which anſwers for a ſmall elevation. The neareſt deſcription of an invention ſimilar to this wheel, which I have

Section & Front View of the German lifting Wheel used in America.

To face page 40.



have met with in any of the Engliſh authors, is that deſcribed by Mr. Ferguſon, in page 152 of his Lectures, under the name of the *Perſian* wheel. This wheel of Mr. Ferguſon's acts in the ſame manner by a flutter board, and diſcharges by ſtriking the bucket againſt a pin at the ſummit point of its revolution: but the German lifting wheel has greatly the ſuperiority in reſpect to ſimplicity and cheapneſs, which brings it within the reach of every man who occupies land; and, poſſeſſing equal power with the Perſian wheel, may be conſidered ſteadier in the fixture of its flutter boards, and the beſt medium between this and the ruder contrivance deſcribed by Sir George Staunton, as one applied to ſimilar purpoſes in China.

IRRIGATION IN FRANCE.

Mr. Young, in his Three Year's Tour through France, publiſhed in 1792, gives a chapter wholly upon the irrigation of that country, from whence many good lights may be derived.

As this work may not happen in the hands of all my readers, I will beg the indulgence of a few extracts from it*. From Limoſin to Limoges, ſays that popular agriculturiſt, every ſpot of land in the mountains is watered that is poſſible; and with ſuch attention, as marks how ſenſible they are of the importance of this improvement. The water is conducted very high up the ſlopes of the hills; and in ſeveral inſtances I was at a loſs to conjecture from whence it was brought. But in the low flat bottoms it is badly done, with lines of ruſhes along the carrier trenches, and little attention paid to the conducting of the water away ſpeedily enough.

* Young's Tour, p. 363.

Near

Near Gange, we are told in the ſame work and page, a ſolid ſtank of timber and maſonry is formed acroſs a conſiderable river between two rocky mountains, to force the water into a very fine canal, in which it is, on an average, ſix feet broad by five feet deep, and half a mile long; built, rather than dug, on the ſide of the mountain, juſt under the road, and walled in like a ſhelf— a truly great work, equally well imagined and executed! A wheel raiſes a portion of the water from this canal thirty feet, by its hollow perripherry. An aqueduct, built that height on two tire of arches, receives the water, and conducts it on arches built on the bridge, acroſs the river, to water the higher grounds; while the canal below carries the larger part of the water to lower fields: an undertaking which muſt have coſt conſiderable ſums.

* Within a few miles of Gange is another ſimilar irrigation; the water is taken from the river in the ſame manner, and lifted equally high by another wheel. The whole way through theſe mountains the exertions in watering are prodigious; there is not an

* Young's Tour, p. 364.

inch,

inch, capable of being irrigated, over which water is not thrown, conducted on the ſlopes of the mountains every where poſſible.

* At Moulins, Monſ. Martin, the gardener of the royal nurſery, who is from Languedoc, waters his garden after the manner of that province. A Perſian wheel of buckets raiſes the water from a well twelve feet, the receiver being placed ſo low as to have five or ſix of the buckets emptying at a time; and very little water is loſt, not the twentieth part, according to all appearance. A horſe turns the wheel. It raiſes two hundred poinçons, each of two hundred bottles an hour. The water is conducted by ſmall channels to all the beds that want it.—I ſhall have occaſion to notice more of Mr. Young's account in another place.

As theſe, however, are improvements beyond ſea, and there may be men who do not chooſe to truſt their monies or belief farther than occular demonſtration upon old Engliſh terra firma, I beg leave to call their thoughts to a few examples in daily practice in their own country.

* Young's Tour, p. 364.

IRRIGATION IN ABERDEENSHIRE:

Its Benefit to Agriculture.

Doctor Anderſon, in his report to the Board of Agriculture on the ſtate of huſbandry in Aberdeenſhire, ſays, * there is perhaps no beneficial practice in agriculture which has been ſo generally neglected in Great Britain as that of watering land. Its fertilizing effects have been ſufficiently experienced in our climate to demonſtrate, that great benefits might be derived from this application of that uſeful element; but we are as yet unable to make even an approximated eſtimate of what the amount of theſe benefits might be, becauſe we know ſo little of the variety of caſes in which it might be applied, or of the preciſe nature of its meliorating effects. Perhaps the application that has been made of it in Aberdeenſhire goes farther to point out the nature of theſe future and diſtant effects, than that of any other part of Britain. It is proved

* Rural Economy of Aberdeenſhire, p. 166.

by

by the practice there, that if a ſtream of water is allowed to flow over the ſurface of a heath-covered moor for a conſiderable length of time, that moor not only looſes the power of producing heath, but it gradually acquires the faculty of producing graſs in abundance, as well as corn, and various other crops that, in its natural ſtate, never would have been reared upon it; and that it not only is enabled to produce theſe crops in conſequence of the moiſture it furniſhes at the time they are growing, but that theſe effects continue after the water itſelf is withdrawn; and that of courſe it operates as a manure, which communicates a permanent fertility to the ſoil that never can be loſt, except by bad management at ſome future period.

In this point of view it would appear, that every drop of water which is allowed to run into the ſea, without having been firſt ſpread upon the ſoil to fertilize it, is a waſte of ſo much valuable manure; and that thoſe who ſuffer it thus to go to waſte, are guilty of nearly a ſimilar crime as thoſe who bury their dung in pits under ground.

They are, however, in the firſt inſtance the more excuſable, becauſe in many caſes the diviſion of property interrupts the pro-

greſs

grefs of water-courfes; and particular fervitudes, that have been eftablifhed in barbarous times, prevent men from availing themfelves of a bleffing, that otherwife might have been within their reach. If it be true, as Swift afferts, "that the man who can make two blades of grafs grow where only one grew before, deferves more applaufe than all the warriors and politicians that ever were born;" it will naturally follow, that thofe who neglect to do this, when it is within their reach, are equally intitled to blame for mifconduct.

Water is peculiarly adapted to the improvement of hilly countries; becaufe thefe from their fituation admit not of any other kinds of manure being carried to them: for very few hilly countries can be found, where, as in Derbyfhire, other manures can be fpread upon them.

But, were a large ftream of water, fuch as the Don or the Dee, taken off at a confiderable height from the fea, and conducted in a level direction for many miles, it would gradually rife to a great height upon the hills, fo as, where the ridges of hills were not difcontinued, to rife even to the tops of very high mountains; all the furface of which,

which, below the level of this ſtream, would gradually be converted into graſs inſtead of heath, were that courſe continued forward even for many miles. And though the whole of that ſoil could not be fertilized at once, yet every moment would be adding to the ſum total of that fertility; ſo as in time to make the whole ſurface of the moſt barren heath-ground as fertile as the moſt luxuriant ſoils.

And were the owners of ſuch ground, in the courſe of conducting theſe canals, to avail themſelves of ſuch occaſional hollows between the mountains as might preſent themſelves below the level of its courſe, the outlets from which could admit of being dammed up, ſo as to be made uſe of as reſervoirs to receive the ſurplus water in time of floods; for the purpoſe of being afterwards diſtributed by lower channels to ſuch fields as were within their influence—the effect would be much augmented. It is in this way that the natives of India form reſervoirs, by them called *tanks*, to be filled with water during the rainy ſeaſons, and afterwards diſtributed over their rice-fields. Some of theſe tanks are many miles in length, and in breadth and ſhape adapted

to

to the nature of the ground: nor are these tanks unproductive of even human food; for besides fishes, which are there caught, the thrifty natives plant their bottoms with the *nymphæ aquatica*, whose large roots furnish a considerable part of their sustenance; and though we are not as yet in possession of any aquatic plant in this climate which could be employed for that purpose, yet were the fields that are thus occasionally employed as reservoirs, laid sufficiently dry when the waters are off them, they would become very productive of herbage, and much more profitable to the farmer than ever they were in their natural state. I know a hollow that is employed for half the year as a mill-pond, and the other half year as a meadow, which lets at a very considerable rent.

So far Doctor Anderson, who, in speaking again conclusively concerning some of the works for public irrigations in France, on the authority of Mr. Young, who I have herein before cited, farther remarks, that as such public works have hitherto unfortunately been confined to warm countries, men have generally adopted the idea that the only use of such irrigations must be to give

moiſture to plants when growing, as the great heat of the climate would deprive them of the requiſite humidity; and that, of courſe, in ſuch moiſt climates as Britain, whoſe plants are rarely killed with drought, they cannot be wanted. He ſtates the fact as clear, however, and gives the practice of Aberdeenſhire as an unexceptionable proof, that water, duly ſpread over the ſurface, and judiciouſly managed, acts always as a permanent manure, that is equally calculated to fertilize the fields and mountains in high latitudes, as to render luxuriant the crops in the vales of torrid regions.

* Let not Britain, then, ſays he, boaſt of her attainments in agriculture, or conſider her fields as nearly as productive as they might be rendered, while ſuch immenſe quantities of water are ſuffered to flow into the ſea, without having ever been employed to fertilize her fields in the ſmalleſt degree.

In theſe poſitions he perfectly accords with my ideas; nor can I perceive any reaſonable excuſe that can be offered for a farther delay of the infinite advantages which may be made to flow from ſo powerful a

* Rural Econ. of Aberd. p. 170.

ſource

ſource as that of national irrigation. That is certainly not among the leaſt agricultural acquirements which enables us to eradicate a uſeleſs heath, and to render it abundantly productive of graſs or corn by the ſimple application of water as a manure: nor can any thing be more laudable than a public attention to theſe eaſy means of multiplying the comforts of the community. But we ſhall explore them to greater advantage in the detail through which we are about to proceed; and I flatter myſelf that the convictions from thence ariſing will be productive of many experiments, and of ultimate happy tendency.

IRRIGATION IN LINCOLNSHIRE.

Sir John Sinclair (fortunately before my work goes to preſs) has obligingly furniſhed me with a reference to ſeveral inſtances of advantageous irrigation; both of the kind which we are to conſider as ſimple watering, and that of a more compound nature, termed warping; which, from the circumſtance of its forming ultimately the whole ſoil or ſu-

 perſtratum,

perſtratum, ſeems decidedly to merit preference as the moſt excellent in the catalogue of liquid manures.

It gives me pleaſure to find, among the ſpirited improvements of the thriving county of Lincoln, an example of irrigation under a head where men of inveſtigation alone will, perhaps, look for it: for it ſeems very inconſiſtent with vulgar perſuaſion and prejudice, that one ſhould ſeek the means of communicating water as an artificial manure, where nature demanded a very laborious operation to drain off a redundancy of moiſture*. Mr. Hoyte, diſcountenancing haſty deciſions on the outward appearance of nature, has been at ſome pains to analize the effects of irrigation; while, by diſcovering, perhaps, the true principles of its beneficial influence, he has ſucceeded in a combination of watering and drainage which proportions the degrees of moiſture, and the fertilizing qualities which accompany them, to the ſucceſſive calls of vegetation; and applies both to the enrichment of the ſoil. I ſhall reſerve the ſubject of warping for its more appropriate place in this work, and, at pre-

* See Lincolnſhire Rep. p. 239.

ſent, take a farther view of the inſtances I am referred to under the more ſimple head of watering.

Mr. Hoyte, of Oſbornby, of whom we have juſt had occaſion to ſpeak, has given farther ſpecimens of his ſuperior ſkill and ſpirit in this kind of improvement, by taking to himſelf an allotment of poor land, for the laudable purpoſe of convincing unbelievers in the theory of agriculture, how very far it is poſſible to practice irrigation with profit. He has availed himſelf of the undervalued reſource of *catch-water drains*, and has irrigated fifty acres at an expence of about fifty pounds*. This improvement ſucceeds to his wiſhes, but it is yet of too recent a date to authoriſe a deciſive account of its product. This Gentleman alſo has obſerved and put in practice a leading maxim in irrigation, which ſeems every where to obtain: he takes care to continue his water (as near as practicable in retaining its nutritious particles) in a conſtant ſtate of activity. His method is to water three or four days, and then ſhift. I apprehend, however, that where irrigation is uſed in a warm ſeaſon, a

* See Agricultural Report of Lincolnſhire, p. 275.

different practice muſt be adopted; and, in this reſpect, a few experiments will be found the beſt preceptor to govern the variance of ſoil and climate. Mr. Hoyte uſes irrigation in the time of froſt for the purpoſe of deſtroying ſedge; which, in his experiment, is ſucceeded by the appearance of white clover.

Mr. Young ſtates the produce gained, in this inſtance, at a ton of hay, and fifteen ſhillings ſpring-feed per acre, with nearly the ſame quantity of after graſs. To this we are to add the advantages of early feed for an increaſing ſtock, and the enrichment of the farm by the proportionate accumulation of manure.

In the Weſt Riding of Yorkſhire, there are ſome inſtances of great advantage derived from irrigating, watering, or floating fields, as it is there termed. Mr. Walker, of Crowſneſt, ſeems to have ſtudied the eaſieſt mode of commanding his water; and Mr. Ellerſhaw, of Chappledale, near Ingleton, deſtroys the moſs by floating in the ſpring ſeaſon.

IRRIGATION IN LANCASHIRE.

Mr. W. Vaughan, of Dunſter Court, to whoſe unceaſing attentions I am inexpreſſibly indebted, has favored me with the papers communicated to the Board of Agriculture by Mr. Holt and others from the county of Lancaſter: from theſe I learn that irrigation is yet in its infancy in that county, although there are a few intereſting inſtances which deſerve notice, and which I am perſuaded, from my perſonal knowledge of that county, may be repeated with a very happy effect.

* It is diſcovered there, by experience, that waters ſtrongly impregnated with metallic or other noxious matter, is improper for the purpoſes of irrigation in the field of agriculture. Water of any deſcription may nevertheleſs prove uſeful to other ends of this ſcience; and in reſpect to its mechanical application, as a moving power, to machinery, perhaps few counties have received greater benefit than that of Lancaſter. Streams of water, which have paſſed unheeded by

* Agricultural View of Lancaſhire, p. 141.

for ages, are ſaid, within a few years paſt, to have proved of more real value to their preſent poſſeſſors, than the real eſtates have been worth otherwiſe to their ſeveral proprietors.

How eaſy would it be for thoſe who have a competent knowledge of hydraulic engineering to convert the numerous little ſtreams of this hilly country to innumerable advantages in agriculture and domeſtic economy. In this ardent wiſh, however, if I may be permitted to indulge an anxious hope for its completion, I would be neverthelefs underſtood to apply irrigation to arable lands; and to be always mindful of the culture of corn, let what may be the gain by grazing.

I find a note or two in this authority, which merit particular notice in regard to the lights they afford on the value of water, even in its neceſſary application to culinary uſes. We are told that a freehold in this county has continued for three generations in the poſſeſſion of a certain family, who (loth, I ſuppoſe, to think themſelves wiſer than their forefathers) have continued in the plain beaten prejudice of carrying a ſupply upon the head in a pail, from a ſtagnant pool at a conſiderable diſtance. The preſent poſſeſſor,

poſſeſſor, it ſeems, purſued the accuſtomed track of the family for about fifteen years; but, in the year 1794, took courage enough to commence the tremendous operation of digging a well: this, within ſix feet of his kitchen door, produced a conſtant ſupply of fine ſpring water, at the very ſerious expence of ſeven ſhillings and ſixpence.

A ſimilar waſte of labour is frequently to be obſerved in driving cattle to a diſtant watering place, when a very ſmall proportion of that labour would bring the water to the farm-yard, and appropriate the ſaving to a more uſeful employment in huſbandry.

There are two examples near Garſtang, in this county, which, from the mention made of them in theſe papers *, deſerve the attention of thoſe who would profit by a combination of irrigation and drainage. One of theſe is by W. F. Brockholes, Eſq. of Claughton; and the other by Mr. Richard Jones, of Peel, in Little Hulton, near Bolton. But, above all other improvements in irrigation which this county ſeems to boaſt, there is one mentioned as an original, which

* See Lancaſter Survey, p. 102.

ſtrikes

ſtrikes my mind with an idea of ſuperior importance. *Mr. Bootle's game-keeper, at Latham*, has, by means of ditches, collected water to a pool upon the higher grounds; this pool is conſtructed with ſides of pounded clay, and the water, in its paſſage to it, paſt the farm-yard and houſes, brings all the fructifying particles with which they are enriched. In this reſervoir the water is retained till wanted in dry ſeaſons, or for other partial applications; and, in the principal channels of diſtribution, he has added marl, through which the water paſſes, and yields thereby an additional fructification.

I confeſs I think the reward given to this game-keeper by the Agricultural Society of Mancheſter has alſo much merit in it—they preſented the good man with a *ſilver cup*. *I* hold this very far more eſtimable, for its purpoſe, than that flatterer of vanity *a golden medal*. The good wholeſome home-brewed ale, with which it ſmiles at Chriſtmas and harveſt-home, will be much more likely to revive an uſeful converſation, and a prompt diſpenſation of its emulating reſults, than the exhibition of a bauble, whereof the

the recollection vaniſhes with the novelty, and whoſe only remaining worth can be eſtimated by the jeweller.

IRRIGATION IN CHESHIRE.

The practice of irrigation by Mr. Fenna*, of Baddly, near Namptwhich, in Cheſhire, is very ſimilar to the method uſed by the German ſettlers in America, in the irrigation of meadows with liquid manure.

The farm-houſe and yard are ſituated upon a ſtratum of clay and marl to a conſiderable depth, and therefore the water, in rainy ſeaſons, is not much decreaſed by abſorption. The ſap from the dunghills, and moiſture from the cowhouſes, &c. is collected into reſervoirs. The moiſture from the waſhhouſe, ſtables, pigſties, neceſſary, &c. which only runs during rain, and a few hours after, is diſtributed into the firſt field by a gutter called the *firſt level*. This farm-houſe is ſaid to be unfortunately ſituated upon the higheſt ground, with a declivity

* See Communications to the Board of Agriculture, Vol. II. p. 334.

from

from it in all directions, which prevents any additional water being brought to it by collecting gutters; and therefore the whole quantity here used is what falls from the clouds upon the buildings, yard, &c. being about two acres of ground; and yet this, inconsiderable as it is, promises to be sufficient for the maintenance and improvement of about eight acres of land for mowing or pasture. The wash from the yard, previous to its being used for floating, proceeds, by means of carriage-cutters, to the lands to be irrigated. It is thence distributed into successive zig-zag trenches, which are carried across the lands which the line of level pursues. This form of trenching is adopted in order to keep an equal level across the ridges and furrows, which the former state of constant ploughing has left irregular on the sides or slopes of the declivities, so that the trenches may be of no greater depths or dimensions in the ridges than in the adjacent furrows, or what, in Cheshire, are called *reans*; and that each level may, when charged with water, discharge it equally over the lowest edge of the trench, from one end to the other at one and the same time.

The

The gutters which are cut in this first field are, at the end where they receive the water from the carriage-gutter, eight inches wide at the top, and six inches deep, sharp at the bottom, or of no breadth, commonly called a prickt-gutter, gradually tapering to the extremity, where it is no more than four inches wide, and four inches deep; they are cut across the declivity of the field, at the distance of ten or fifteen yards from each other. The sod, taken from a gutter of this sort, is prismatic or wedge-like; and one of the largest, at the end adjoining the carriage-gutter, is retained and used for a stop, and placed either in the collateral level, or the carriage gutter, as occasion may require; the others have here been chopped to pieces, and spread in the furrows or *reans*, in order in time to make the field more upon a level. Where not wanted to level hollow or low places, they should be carried into heaps and mixed with dung for a compost. There is no part of any gutter raised by the stuff taken out, and therefore the mower meets no more obstruction than he did previous to their being cut.

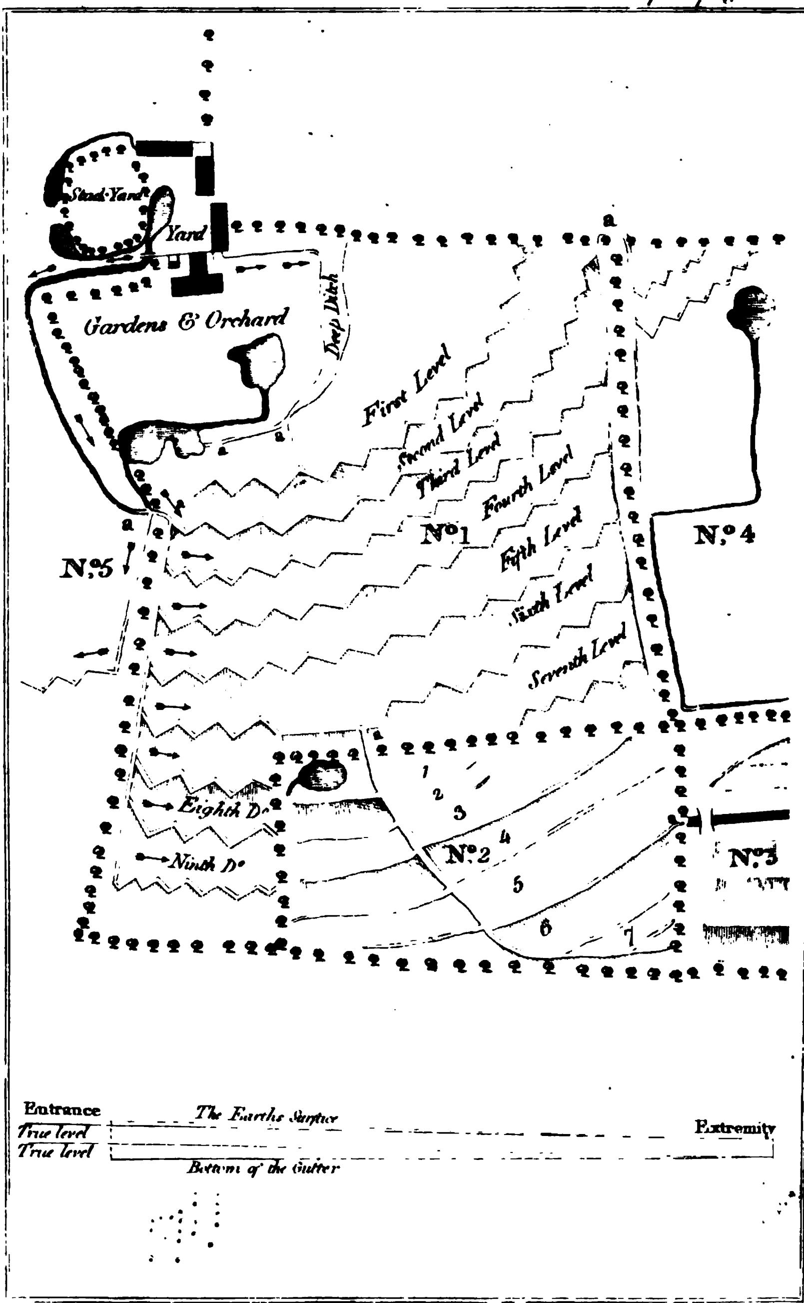
Method

Method of floating the fields.

When it rains, the reſervoirs are pounded up as high as they can be, without injury to the yard, whilſt the rains from the other ſide of the buildings, including the waſh from the waſhhouſe, pigſties, neceſſaries, &c. are collected into one gutter, or deep ditch, and turned into the firſt level by the ſtop; which level becomes thus filled from end to end, and flows down the declivity of the field: but the tendency the water has to quit the ridges, makes it neceſſary to cut a ſmall channel in each ridge, two inches wide and two inches deep.

After paſſing over the ſlope, or part immediately below the firſt level, it is again collected by the ſecond level, and diſperſed over its flat; and in the ſame manner over the third, fourth, fifth, and ſixth levels. But when the water is wanted for another meadow, one of the levels, ſuitable thereto, becomes a collecting gutter, and by a proper removal and management of the ſtops, its contents

To face page 63



contents are poured through the gateways a a a a, into the field for which they are demanded.

Thus each level and field is alternately managed as occaſion requires; and, one or two days after the rain ſhall have ceaſed or abated, when the ſurface of the field appears dry, the reſervoirs of black thick water are let out and diſtributed where they are needed moſt. The reaſon why theſe were not let out ſooner was, the quantity of rain happening to fall might, perhaps, have carried it off over the ground; and the reaſon why it ſhould not be uſed later, or in dry weather, is, the ground is then open and porus, and the reſervoirs do not hold a ſufficient quantity to reach far upon the field.

Thus it appears that a due obſervance of the declivity and points of diſtribution, will render the ſame gutters and trenches, duly managed by the ſtops, alternately works of irrigation and drainage; and, a ſimilar attention to the ſtops, will either diſtribute the water through the ſucceſſive levels, or partially to any which you would uſe for irrigating by the continuance of the carrier-trench, and turning off the needleſs levels of the time.

The

The declivity allowed to theſe levels is an inch to every ten rood: this is ſufficient to carry forward the water through its various operations. Hence you may either flow the whole levels and fields in ſucceſſion, or you may flow the fields in rotation, according to the number of them which are connected with your works.

In other fields, on the eſtate of Mr. Fenna, we find he contrives to collect water in the time of rains, from all the grounds which lay upon a higher level than thoſe which he deſigns to irrigate. This method ſhould indeed be obſerved in all caſes of irrigation; for by means of ſuitable catch water-drains along the ſides of more elevated lands, leading to reſervoirs dug on eligible ſcites, it is very practicable to irrigate lands, either with ſimple or compound liquid, although there be not any other water to reſort to than that which falls from the heavens.

Gentlemen who wiſh to purſue this method of irrigation, with minute attention to the ſyſtem practiſed by Mr. Fenna, will do well to refer to this gentleman's detail deſcription, as communicated to the Board of Agriculture. It is to be lamented that we

are

are not fully favoured with thofe refults of his crops which authorife computation. I have endeavoured to give his principles fuccinctly, but fufficiently to authorife an imitation, which will neceffarily vary according to the circumftances connected—and genius muft be greatly relied on. I take the liberty of recommending, however, the employment of an engineer, who has made thefe points his ftudy; and I have no hefitation in foretelling, that the refult will return an ample compenfation for the aid of profeffional fkill.

IRRIGATION IN GLOUCESTERSHIRE.

In 1789, the Reverend Mr. Wright publifhed a fmall, but valuable pamphlet, on the art of watering meadows, as it is practifed in Gloucefterfhire. This was printed at Cirencefter, and as I have been fortunate enough to procure a copy of it before I clofe my work on this very interefting topic, I will endeavour to diftribute the principal points of his communication to the farther advantages of agriculture.

In the preface of this uſeful little work, the author, very properly, goes into a previous explanation of the terms of art which are applied to deſcribe this ſcience in Glouceſterſhire; for it is to be lamented, that terms of art, as well as provincial phraſeology, are not yet reduced to any uniform ſtandard within the ſphere of a modern dictionary.

The *works* (ſays he) are the large ditches, by which the water is introduced into the meadow.

The *trough* is a ſmaller ditch, which branches from the works.

The *ſtop* conſiſts of one, two, or more ſtakes, driven down in the middle of the works and troughs, to obſtruct the courſe of the water, and to keep it high enough to flow through the ſluices.

The *ſluice* is a ſmall apperture made in the ſides or banks of the works and troughs, at the diſtance of one or two yards, and through which the water paſſes that covers the ſurface of the land.

The *drains* are ditches cut in various directions, and different dimenſions, reſembling the branches of a tree, and all terminate

minate in one large trunk, which carries the water back into the ſtream.

The advantages (ſays he) ariſing from this mode of watering are many and great. If it be well executed, I may freely venture to aſſert, that this mode of cultivation will be found more productive than any modern improvement in agriculture. By it land, whatever its kind or quality, is increaſed to *double* or *treble* its former value. And it does not derive this enriching power from the aſſiſtance or ſpoil of the neighbouring lands, but it diffuſes a general fertility. It does not rob the farm-yard of its ſtores, nor even take back from the abundance which it there produces; for it ſtands in need of no dung, no expenſive preparation of manure or compoſt. So that the farmer, who occupies fifty acres of this watered land, has an hundred tons of hay to carry off and ſpend upon his other grounds. But it is not merely the crop which conſtitutes the excellence of watering; it is the *earlineſs* and *certainty* of the crop.

Every intelligent farmer is ſenſible of the great value of graſs very early in the ſpring; and we, by watering, have plenty of graſs at the beginning of March, and when the

ſeaſon is mild, ſomewhat earlier. The good effect this graſs has upon cattle that have been unhealthy or hard-wintered, is aſtoniſhing. The ſecond week after turning into the meadows, a very viſible change is made in all cows, horſes, and ſheep: and the farmers are here enabled to begin cheeſe-making at leaſt a month ſooner than their neighbours, who enjoy not the benefit of watering their land. And in fatting of lambs, the value of graſs is ineſtimable.

With regard to the certainty of a crop I need not ſay much; the thing will ſpeak for itſelf. Between March and May we are ſure of ſpring-feed that is worth, at leaſt, a guinea per acre; in June we have a crop of graſs that will yield two tons of hay per acre; and the latter-math is always worth a pound. Let the ſummer be ever ſo dry, we have nearly the ſame quantity. After the laſt dry ſummer, the advantage of watering was evident; for the neighbouring farmers were obliged to come hither to buy hay, at whatſoever price the owners thought proper to demand.

Other advantages of watering there are which ought not to be paſſed over unnoticed. The land thus treated is continually im-

proving;

proving; its herbage, if coarſe, is fined; its ſoil, if ſwampy, becomes ſound; and an addition is made annually both to the depth and quality of its mould.

As a kind of proof of ſome of the above aſſertions, I ſhall thus inſtance the product of one of our meadows this preſent year. It is one that has been watered longer than the memory of the oldeſt man in the pariſh; but it is by no means the beſt meadow upon the ſtream, nor has this year been a favourable one for watering. It is about ſix acres and a half. The ſpring-feed of it was let for ſeven guineas, and well ſupported an almoſt incredible number of ſheep (an hundred and fifty), for two months; the hay was ſold for thirty-two guineas; and the latter-math for ſix.

Mr. Wright then proceeds to a preference to muddy or ſaturated water, which Mr. Boſwell, I find, conteſts in favour of *limpid* water: poſſibly both may be right under a difference of circumſtances. I ſhall therefore paſs over this particular, referring thoſe to a compariſon of their reaſonings who may wiſh *chemical* ſatisfaction on this head; it appears pretty clearly, I think, that the practical facts are good in both inſtances

and practical experiments will be the beſt guides on every variety of ſoil and ſituation.

Mr. Wright ſtates the quantity of land irrigated in his pariſh to be three hundred acres; and the ſtream, from whence the water is drawn, to be moſtly equal to a ſection of five yards by one—but ſeldom to exceed ſuch dimenſions.

The three following things, this gentleman tells us, are neceſſary to be conſidered:

1. "Will your ſtream of water admit of a *temporary* * wear or dam acroſs it?"

2. "Can you dam up and raiſe the water higher than any part of your meadow, without flooding and injuring your neighbour's land?"

3. "Can you take the water off your meadow as quick as it is brought on?" And he might have added, in regard to the preſent improved knowledge of mechanical powers,

4. Can you apply machinery, moved by wind, by water, by ſteam, or by animal

* Mr. Boſwell, in his Treatiſe on Water-Meadows, p. 116, objects to TEMPORARY wears; for reaſons which appear to have ſome weight in reſpect to ſubſequent injuries from their remains. Much in this caſe, I think, may depend on the quality of the ſoil and wear.

labour,

labour; as the power of motion, to convey water over your land, at an expence which will bear a light proportion in the ſcale of preponderating profit?

If you can anſwer ſuch of theſe queſtions in the affirmative as apply to your particular caſe, I have no heſitation in ſaying you ought to proceed immediately to erecting works for agricultural irrigation; and if you do not do it, you will repent every year's neglect.

In this caſe, if you prefer the Glouceſterſhire method, you will conduct the water along the higheſt part of your meadow, by means of a deep wide ditch, ſuch as they term the *maſter-work,* the banks whereof ſhould be of an equal height, and a few inches higher than the general ſurface of the meadow. In large meadows, ſuch works muſt be repeated according to the diviſions of the ground. Theſe ditches ſhould be about nine feet wide, and a proportionate depth, to a plat of about fifteen acres. And theſe works are ſometimes repeated in number, ſo as to give ſucceſſive waterings to larger tracts.

Smaller *ditches* or *troughs* are to be cut from theſe, at nearly right angles, and their

refpective widths to be, of courfe, proportioned to the diftance they are to be carried, and the demand of the part to be irrigated.

The diftance of thefe ditches from each other fhould be about ten or twelve yards. Ten yards wide upon the furface may be watered by a ditch of two feet wide, and one deep. Mr. Wright limits thefe kind of troughs to forty yards long; but, if the fupply of water is fufficient, I fee no difference between the diftance of forty yards and forty miles, where repeated communications can be made with the work. In each of thefe troughs frequent ftops are to be placed, efpecially where the water is rapid, in order to keep it high enough to flow through the fluices, or over the fides.

It is obvious that the works and ditches, or troughs, may be diminifhed in their progrefs downwards; for this operation, which diftributes water to a thirfty foil, which retains a proportion as it paffes, is evidently the reverfe of the operation of drainage, which draws off the fuperabundant fupply of moifture, in a ftate of continual accumulation; and requiring a wider fewer in its progrefs towards the fea, upon precifely the fame principles of ramification which nature

has

has employed in the formation of rivers. Wherever the water feems inclined to ftand, a drain or narrow ditch is to be immediately cut into the main drain which carries off the water.

In cold flat, fwampy meadows, Mr. Wright fays that the diftance between trough and drain ought never to exceed four or five yards. The fall of the ground he alfo regulates at half an inch per foot for meadows. He fays the water fhould never flow more than two inches deep over the land. When the grafs is two inches high, he is of opinion the water fhould never fhew itfelf, except in the ditches. I apprehend, however, that in very thirfty lands or warmer climates, it will be better to refort to a little local experience, than to confine the operation to the obftinate rule of a limited fpot. In this refpect, when Gentlemen think proper either to fend their own farmers to learn the art in an irrigated country, or to employ a profeffional irrigator from thence, I would recommend the addition of their own judgment on the principles of natural philofophy. In hot countries I have had fufficient experience to convince me, that few graffes will

will ſtand watering under the immediate influence of the ſun; but if you ſuffer the ſun to go down, and avail yourſelf of that moment to irrigate your lands with an hour or two's flow of water, taking care to turn it off at the expiration of that time, you may ſafely, I think, uſe this mode of irrigating graſs, and perhaps grain, throughout the earlier ſtages of vegetation, until it appears to be time to let the natural proceſs of ripening commence. A method of this kind will furniſh a pearly dew every morning through the heat of the ſummer; and I take that to be a degree of moiſture which is the moſt agreeable to the natural requiſitions of the vegetative principle.

Sometimes, Mr. Wright tells us, it is neceſſary to carry the drains under the works and troughs, in order to get rid of the ſurplus water after it is uſed. In this caſe, it is the practice in Glouceſterſhire to make uſe of boards, and boards and planks, for conveying the water above in the manner of an aqueduct over a river; and this is here termed a carry. For the better regulating the diſtribution of the water in ſpring, it is alſo cuſtomary to dig ſmall temporary trenches where

where they ſeem to be moſt wanted, laying the ſod or mould by the ſide of them, that it may be replaced when the watering is over. In replacing this ſod, the irrigation ſhould always look forward to the ſcythe, ſo that this may not prove a future obſtruction to mowing.

Mr. Wright ſpeaks of grounds which have been ploughed into broad lands and furrows as the beſt ſhape for irrigation; becauſe ſuch ſhape admits of conveying the water quickly along a ſmall ditch upon the ridge, and paſſing it off by the furrow.

Every meadow ſhould therefore be brought into this ſhape, according to his recommendation; though it is ſometimes neceſſary to make three works, one acroſs each end of the land, and one diagonally. It is clear to me, however, that genius and experience muſt be employed in this reſpect, according to the nature of each particular caſe.

When the lands are thus prepared for irrigation, the Glouceſterſhire method of applying the water is as follows: in the beginning of November they cleanſe all the works, troughs, and drains from graſs, weeds, and other impediments; and repair the banks, if they are injured by the feet of cattle or other caſualty.

casualty. The opportunity of the first shower is then seized on, for the purpose of irrigating with as much muddy water as possible; the richness and salts, which the waters are supposed to contain in greater abundance at this season, are thus deposited as a manure to the impoverished soil, and the water taken off in about three weeks.

The Author of a late History of Cirencester, who has followed a later edition of Mr. Wright's pamphlet than I have seen, says, that in December and January care is to be taken that the land be sheltered by the water from the severity of frosty nights. But it is necessary through the winter, every ten days or fortnight, to give the land air for a few days, by taking the water entirely off, otherwise it would rot the roots of the grass. And every meadow should be surveyed twice a week, to see that the water is equally distributed, and to remove hurtful obstructions from sticks and weeds.

In February much caution is necessary, if the water remain on the meadow for many days without intermission, as it will generate a white scum, very destructive to the grass. On the other hand, if it be taken off, and the land exposed to a severe frosty night, without

without being previoufly dried for a whole day, it will cut off much of the tender grafs. To avoid thefe injuries, take the water off by day, to prevent the fcum, and turn it over at night, to guard againft the froft; or both may be avoided, by taking the water off entirely for a few days and nights, provided the day on which it is taken off be dry; for after one fine drying day, a froft at night will do the grafs little or no injury. Towards the middle of this month, ufe only about half as much water as in the winter. Rather wet than water; for at this feafon it is only neceffary to keep the land in a warm humid ftate, to force vegetation.

At the beginning of March there is generally on fuch meadows abundant pafturage for all kinds of ftock. But the water fhould be taken off for nearly a week before heavy cattle are turned on; and if the feafon be cold, it is proper, during the firft week, to give the ftock a little hay at night.

Some perfons eat off the fpring feed with ewes and lambs, by enclofing them with flakes or hurdles in a certain portion of it every day, giving hay at the fame time. This is certainly making the moft of the grafs, and an excellent method to fine and

fweeten

ſweeten the future herbage. In March and April the graſs may be eaten as ſhort and cloſe as poſſible, but never later. If the month of May be treſpaſſed on for only a week, it will very materially impair the hay crop; the graſs will be ſoft and woolly, like latter-math.

When ſpring feeding is finiſhed, the water is again neceſſary for a few days by way of wetting.

It is remarkable, that watering in autumn, winter, and ſpring, will not occaſion the rot in ſheep; but has been known to remove the cauſe from meadows which had rotted. But if the water be uſed, though only for a few days, in any of the ſummer months, the paſturage will be unſafe for ſheep. Take one inſtance: at the beginning of July, the hay being off, and the river very muddy from abundant rain, the water was thrown over a meadow for ten days; in about a month the ground was covered with an uncommon luxuriance of herbage, into which eight ſound young ewes, and two lambs, were turned to depaſture: the lambs were killed ſix weeks afterwards, and had ſymptoms of rottenneſs; and in about a month or ſix weeks more, the ewes were alſo killed,

and

and though they were very fat, their livers were putrid, and replete with the insect called the fluke, or weevil. This experiment ascertains the event, and, at the same time, proves that muddy water in the summer is much richer than in the winter or autumn, and may be very advantageously used, for a week at least, every wet summer, notwithstanding the inconvenience as to sheep.

All objections to watering meadows after this method, such as cutting the ground, laying out meadow, and other expences; that hay thus produced is inferior to upland hay, &c. are abundantly countervailed by the advantages. The coarseness of the hay is obviated by cutting early, when it will be excellent: but those who are covetous of having nearly three tons to the acre, must be content with long, coarse hay.

The advantages are, the land and herbage are continually improving, without manure; the crop is not only full and certain, but it is also early. And who is not sensible of the astonishing effects of early grass on all sorts of cattle, but particularly sheep and lambs?

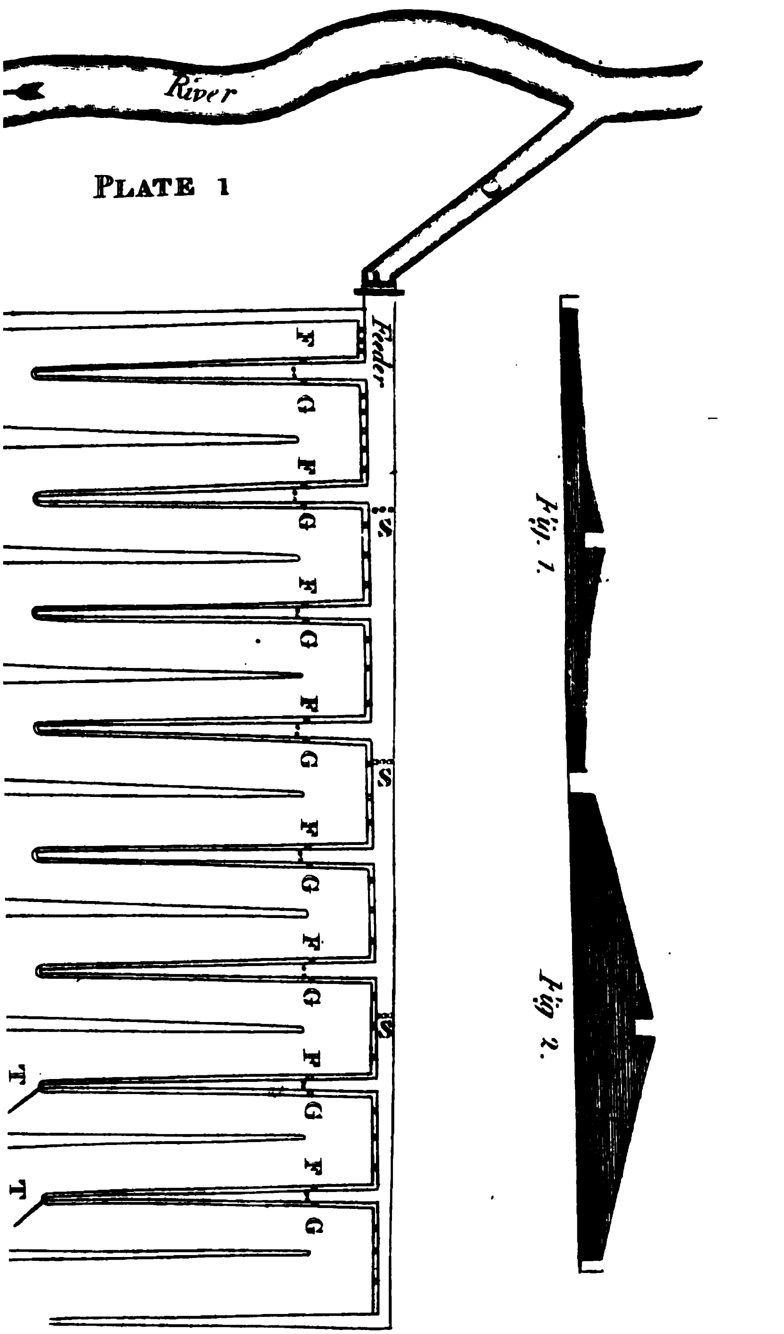
With

With theſe advantages, it is ſurpriſing that the practice has not long ſince become general throughout the kingdom. In this neighbourhood the moſt inſignificant ſpring or rivulet is not ſuffered to paſs unreſtrained; and whenever a ſudden ſhower occaſions a temporary flood, proper ditches are made to receive the water, and to ſpread it equally over the land; but there is no ſtream or river on which a mill is or can be erected, but what may be made very enriching to a certain quantity, if not a large tract, of land.

In levelling a work for irrigation, care ſhould be taken to proportion the current to the diſtance: for example, if the diſtance is one hundred yards, and the fall four inches, then it is one inch fall to each twenty-five yards, and ſo in proportion.

Expla-

PLATE 1



Girtin sculp.

Explanation of the annexed Plates, from the Hiſtory of Cirenceſter.

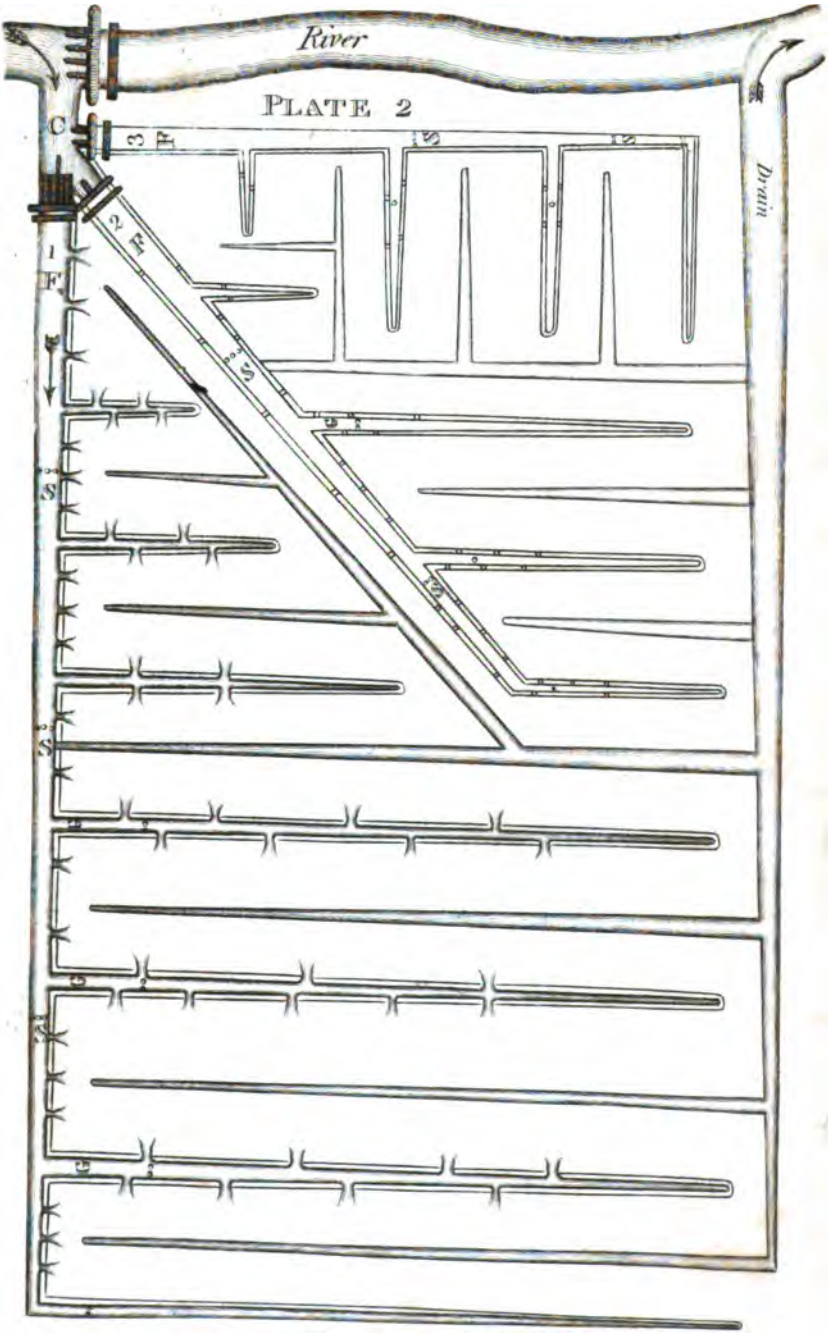
PLATE I.

Repreſents a meadow regular in its ſurface with the current of the river, but too high to be floated from the part of the ſtream immediately oppoſite to it. In order, therefore, to gain a fall, the water is taken out at a higher part of the ſtream by a conductor, as at C, into the feeder, which is cut along the higheſt part of the meadow, and has a flood hatch in the mouth of it, to admit or exclude the water at pleaſure. This conductor we will ſuppoſe, for the ſake of illuſtration, has only four inches deſcent in its whole length, but the ſtream in the ſame length falls ten inches; therefore, ſix inches of power are gained by means of the conductor, which is a fall abundantly ſufficient for floating the meadow. By this mode of gaining deſcent, thouſands of acres may be floated, which ſome would think impoſſible to be done.

Fig. 1 and 2 reprefent a tranfverfe fection of two ridges, with their fides or beds an inlined plane. The floating gutters, or troughs, as we fometimes call them, (marked F. G.) are drawn with double lines; and the ftops in thefe and the feeder are marked with fmall circles and the letter S. The drain cuts are made with fingle lines.

PLATE II.

Reprefents a floated meadow, which had three parts confiderably higher than the general furface of the land. In order to throw the water over the higher parts, it was neceffary that each fhould be accommodated with a feparate feeder, as fhewn in F. 1, F. 2, F. 3, with its ftops, gutters, notches, and drains. In this method the floating may be alternate through the winter.



Girtin sculp^t.

To face page 83.

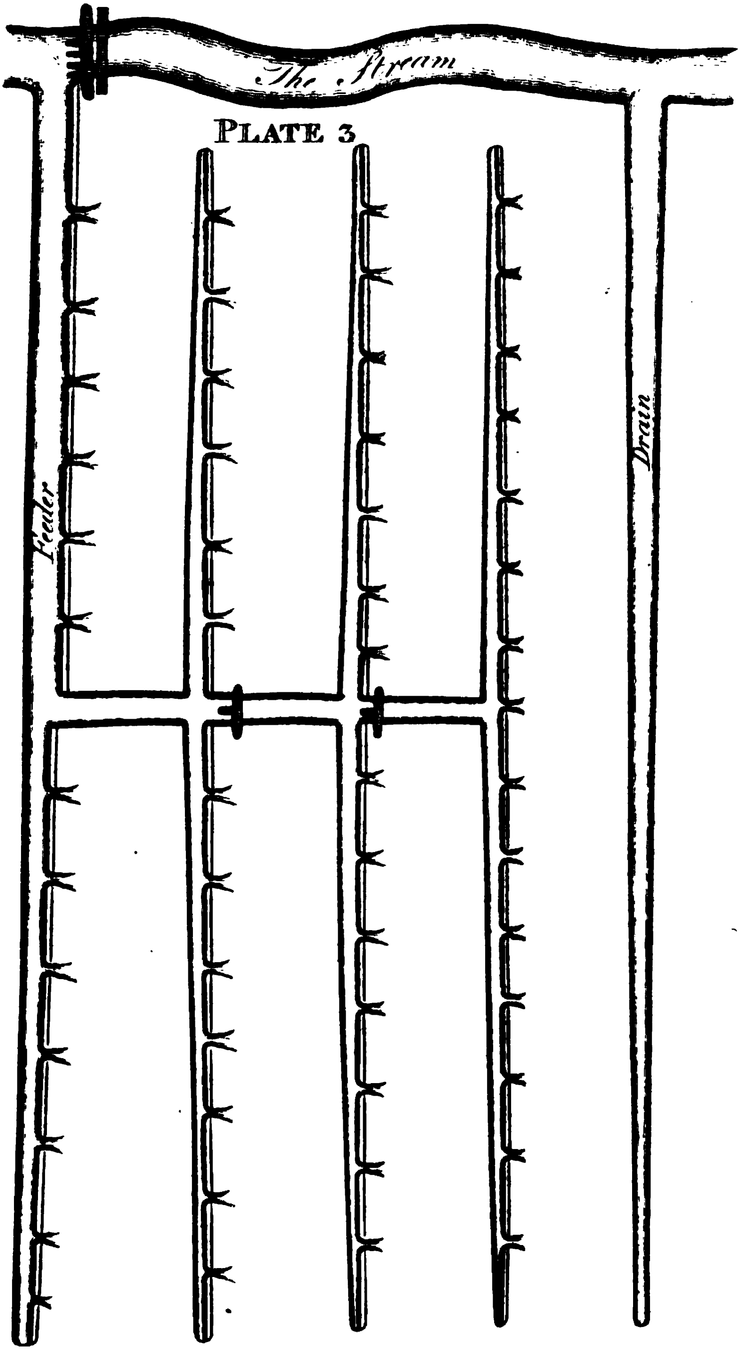


PLATE 3

Plate III.

Reprefents a fort of floating commonly called *catch-work*, where the ditches are made at a diftance below each other, acrofs the declivity, to catch the water, again and again, from the top to the bottom of the meadow. It is evident that the upper beds muft receive more than their fhare of the nutriment that is depofited. This method fhould never be ufed but where the declivity is too great to admit the floating gutters to point down the defcent, as in the other method.

In December and January, ſays Mr. Wright, they are careful to ſhelter the lands from froſty nights, by keeping the water flowed over it. In February they enjoin a more particular care not to let the water remain many days, on account of a white ſcum which ariſes, and is very injurious to the graſs; and the danger of killing the graſs by the froſt at this ſeaſon.

The only way to avoid both theſe riſques, Mr. Wright ſays, is to take the water off in the day, and turn it on at night; for it is only when the graſs is wet, that the froſt is ſo pernicious.

Mr. Boſwell, on the contrary, condemns this doctrine, and ſays, that although the warmth of the ſun is ſeldom ſufficient to have an effect upon the water in the month of February, that it is not uncommon in that month to have the waters kept upon the meadows for a fortnight or more; and that as the froſt ſometimes freezes up the hatches or flood-gates in one night, meadows are covered for ſeveral weeks with ice; and that when the froſt is gone off, thoſe meadows always ſhew the fineſt verdure ſooner. I incline

incline to coincide with Mr. Bofwell on what I have remarked in regard to a crop of wheat being covered with fnow, as a fhelter againft the chilling blaft; and for fome other reafons which are better explained in my two papers, publifhed in the two Numbers of the Monthly Magazine, for the months of February and March laft, on the caufes which affect the climate of North America: yet I am loth to diftruft Mr. Wright's obfervations, and am rather difpofed to believe that there is fome overfight in the bufinefs, or fome unobferved principle or other which might reconcile their feeming contradictions.

Mr. Wright feems to think, that as much water as will cover the furface barely, is fufficient at this feafon. Mr. Bofwell thinks otherwife. At the beginning of May, juft after the fpring feed is eaten down, the meadows are to be irrigated; and the fame fhould be done after taking off the hay. I myfelf have a tract of land in the Tennaffee country in N. America, upon which I refided during the hard winter, 1779-80. On this tract was a fmall piece of upland meadow, of the kind of grafs known in America by the name of *Timothy*, but the Englifh name of

which is unknown to me *. The ſnow was at this time and place nearly ten inches deep; and ſo frozen, for nearly ten weeks without intermiſſion, that the waters were cloſed up, ſo as to produce an amazing deſtruction of outlying cattle and horſes; the deer and other game ſuffered almoſt an extirpation in many of the neareſt hunting grounds; and, without exaggeration, the wild turkies were ſo tamed from the trees, as to feed among the poultry at the cottage doors. Even this ſevere froſt had no effect on the Timothy graſs; or, at moſt, a very partial one; and the herbage of the meadow made an early and luxuriant appearance on the approach of ſpring.

I have not been able to come at Mr. Blythe's work, the *Improver improved*, of which Mr. Boſwell ſpeaks highly, as a uſeful book on Agriculture, and in reſpect to its general information on the ſubject of irrigation. But I ſhall endeavour to draw from the latter ſome of thoſe uſeful lights which may be reaſonably expected from ſo able a practical farmer.

* Since writing this, I obſerve Mr. Strickland ſuppoſes it to be the *phleum pratenſi* of Withering, variety *nodoſum*.

This

This gentleman adopts Mr. Kent's maxim, in which all the practical farmers we meet with feem to concur; and many of them adduce the moft fatisfactory proofs of its folidity*. "*Flooding is truly the beft of all improvements, where it can be effected; and there ought not to be a fingle acre of land neglected which is capable of it.*"

Mr. Bofwell, fpeaking of the kind of lands which are *capable of being watered*, goes into qualities of the foil, and circumftances which feem proper fubjects of information to practical irrigators, who fhould endeavour to know every thing. In regard to the proportion of lands which may be watered, he feems to confine himfelf to thofe principally which come either under the level of nature, or require very little affiftance of art. But as my idea of adopting *national machinery*, is competent to humble the mountain top to the offices of aration, I fhall pafs this part over.

It feems proper to take notice of the various implements of irrigation which are ufed in Dorfetfhire, according to Mr. Bofwell's

* Kent's Hints to the Landed Intereft.

well's method of watering. He enumerates the water-level; the line-reel, and breaſt-plough; ſpades, peculiarly adapted to irrigation; the creſcent; wheel-barrows; hand-barrows; three-wheeled carts; ſcythes; forks; long-tined crooks; ſtout large water-boots. I ſhall venture to give his explanation of ſuch as are out of the courſe of ordinary obſervation; uſing my own remarks where I think an advantage may not have occurred to him.

Water-levels.

As the ſcience of levelling is reduced to mathematical nicety, and a great variety of inſtruments are now in uſe among profeſſional engineers, ſuch as every gentleman ſhould employ where he means to render his works permanent and effective, I ſhall only notice ſuch rules of conducting the levels of irrigation as are commonly obſerved by the workmen. The workmen, Mr. Boſwell* ſays, diſpenſe with the uſe of the inſtrument,

* Boſwell on Water Meadows, p. 16.

bringing

bringing the water after them to work by. In drawing *a main*, they begin at the head, and work deep enough for the water to follow them. In drawing a *tail drain*, they begin at the lower end of it, and work upwards, to let the *tail-water* come after them. —This method obtains the exacteſt level.

The line, rule, and breaſt-plough.

I ſhall ſay nothing of the two firſt, which are known to every body. The breaſt-plough is an implement uſed in the agricultural office of *burn-beating*, or *denſhiring*. It is formed ſomewhat in the manner of a ſpade, with broad wings ſuitable, to take a good width of ſod or ſwarth; for the getting whereof it is much uſed in the County of Lancaſter, and other turf countries. It is fixed upon a long handle or helve, with a croſs handle and breaſt-piece to reſt againſt the breaſt of the man, who uſes it by puſhing it forward before him. By giving the blade of the ſpade a ſuitable ſhape, it may be alſo uſed to advantage in clearing out the bottom of drains, ditches, &c. There is a ſimilar

ſimilar implement uſed, in Lancaſhire, in a different way, by puſhing it with the thigh, againſt which a large wooden head or button is ſo contrived as to reſt.

Spades.

The ſtems of ſpades for irrigation are conſiderably more crooked than other ſpades; ſo that the workman, in the bottom of the ditch, may be able to make his drain or trench ſmooth and even, when ſtanding in a working poſition. The bit is made of iron, about a foot wide in the middle, terminating in a point, having a thick ridge down the middle, and thin and ſharp on the edges: when worn thin and narrow, theſe are uſed for the ſmaller trenches, and others are replaced for the larger.

Creſcent.

This inſtrument is made like a gardener's edging knife, but larger, in the form of a creſcent, very thin and well ſteeled, having a ſtem

a ſtem about three feet long, with a croſs-handle to bear upon. Its uſe is to trace out the ſides of the mains, trenches, drains, &c. which, Mr. Boſwell ſays, it does very expeditiouſly, and with eaſe to the workmen, where the land is free from ſtones.

Wheel-barrows.

Thoſe for this uſe are made *open*, without ſides or hinder part. They are principally for conveying ſods, &c.; for embanking, damming, &c.

Hand-barrows.

Where the ground is ſoft and flooded, it becomes neceſſary to ſubſtitute theſe in lieu of wheel-barrows, for conveying clods of earth, &c.

Three-

Three-wheeled Carts.

Theſe appear to be in uſe in Dorſet; and I preſume with a broad tread or tire. Their utility in water-meadows is obvious; as the wheels do not follow each other in the track, and as a proportion of the weight is borne upon each wheel in a triangular form, which will be leſs ſubject to cut and ſink into the ſoil.

Scythes.

Both ſhort and narrow ſcythes are implements of frequent uſe during the running of the water: they are then uſed to take away the weeds and ſuperfluous graſs.

Forks and Crooks.

Theſe are conſtantly wanted during the times when it is neceſſary to clear the drains of weeds and roots. The crooks are formed with

with long tines for this purpofe, fimilar to a dung-dragg. Thefe fhould be made light and with long ftems, fo that the workmen can reach into deep water with them, to clear the ftream from obftructions.

Stout large-topped Boots.

The tops of thefe fhould draw halfway up the thigh or better; they fhould be ftout leather, well greafed with tallow, fo as to refift running water for ten or twelve hours together; and fhould be large enough to admit of ftuffing them down with hay all round the legs. The watermen's boots ufed in the New England and Newfoundland fifheries, would apply well in this cafe. There are feveral other implements that Mr. Bofwell has not noticed, which appear to me to apply well to the management of water-meadows, where there are hedges, woody countries, briars, &c.—Such, for inftance, as *fprouting-hoes*, *weeding-hoes*, *briar-hooks*, *mole-rakes*, *dock-crows*, *gripes for drawing weeds*, *horfe-fleighs*, *turf-fpades*, &c. which, I think, will often be found

A *trunk* is literally a covered ſluice, and is ſo conſtructed in all caſes where two ſtreams of water are to croſs each other at the point of diſcharge, or if it is to ſerve as a bridge.

A *carriage* is a ſmall ſpecies of wooden or brick aqueduct, built open, for the purpoſe of carrying one ſtream over another. Mr. Boſwell conſiders this the moſt expenſive conveyance belonging to watering.

A *drain-ſluice*, or *drain-trunk*, ſays Mr. Boſwell, ſhould always be placed in the loweſt part of ſome main, as near to the head as a drain can be found that is ſituated low enough to drain the main, &c. It is placed with its mouth at the bottom of the main, and let down into the bank, and from its other end a drain is cut to communicate with ſome trench-drain that is neareſt. This contrivance is uſed to carry off the leakage through the hatches when they are ſhut down to convey the water to other grounds, or to repair the main, &c.

Hatches ſeem to be literally another name for flood-gates, and applied to the ſame purpoſes; they may, of courſe, be variouſly conſtructed. Mr. Boſwell uſes a particular kind, with about a foot to take off, ſo as

to

to permit the water to flow over that much of the hatch where it appears to be ufeful in irrigation. This method might, I think, be improved by conftructing the hatches in the manner of the kind of Venetian fhades which turn upon an axis.

A *head-main* fignifies that part of the principal ditch which takes the water firft out of a river or ftream, for the purpofe of diftribution through its fmaller ramifications.

Small mains are the next gradation of ditches which are applied to diftribution, by means of their communication between the head-main and trenches. Thefe are, by fome, confounded with other works, by the term *carriages*.

A *trench* is the laft diftribution-ditch in watering, continuing to decreafe its dimenfions as it fpreads the water over a greater extent of ground.

A *trench-drain* is a deep ditch or drain which meets the trenches, for the purpofe of taking the water away fpeedily after the irrigation is performed. It fhould be cut parallel to the trench, and as deep as the tail-drain water will permit; if poffible fo as to reach the ftratum of fand, gravel, or clay—a fpade's depth into the laft would be an ad-

 vantage.

vantage. Its gradations are exactly the reverse of the trenches, which it meets in the manner of two forks, placed with their points into each other at regular distances. Its parts, of course, increase as it receives successive streams to be drained off.

A *tail-drain* is the principal ditch which conveys the water out of the meadow. It receives that which all other drains discharge, and should consequently lead to the lowest possible point of discharge, and the nearest direction which the ground, under every circumstance, will permit. If used as a fence-ditch, this answers a double purpose.

A *pane* of ground signifies the part containing the grass to be mown between the trench and trench-drain: each of such strips of land are called *a pane.*

A *way-pane* is the strip of land left for cartage, along the side of the main, being watered from the banks of the main, and drained by a parallel ditch.

A *bend* is defined by Mr. Boswell to be, a stoppage made in various parts of those trenches which have a too quick descent, in order to check the water and force it out of the trench. This is done by leaving small

dams

dams of the natural ſward at proper places, and cutting a ſod out of them wedgeways; ſo as to limit the impetuoſity of the current and give a more equal diſtribution of the water.

A *gutter* is a ſmall grove cut from the tails of the trenches, occaſionally, to diſtribute the water to the utmoſt extent of the panes more equally than could be effected by the regular works, ſo as by this means to avoid patch-work or omiſſions.

A *catch-drain* is an occaſional ditch which is ſometimes cut to carry the ſame water into a ſecond main, for the purpoſe of irrigating a lower meadow or pane with the ſame water which has been uſed. The watermen conſider it then, however, to be in an impoveriſhéd ſtate, on account of the particles juſt depoſited, or communicated to the lands above.

A *pond*, in irrigation, is applied to any ſpot of ſtagnant water, which is left on the ground in the proceſs of irrigation, to the detriment of the crop.

A *turn* of water, ſignifies as much as can be diſtributed at a ſingle operation, by the management of the hatches within reach of

the labourers employed, and as the ftre m will fupport.

The *head* of the meadow is that part into which the *main* firft enters.

The *tail* of the meadow, being the reverfe, is that part where the tail-water laft paffes off by the tail-drain into the natural fewer; or where that fewer itfelf leaves the meadow.

The *upper* fide of the meadow, is that which fronts the point at which the main or river entered.

The *lower* fide is, confequently the reverfe of the above.

The upper *pane* is that which lays above the main, if fuch a one be left.

As gentlemen who incline to irrigate their eftates will, doubtlefs, procure the aid of practical men, and experienced examples as far as poffible, I fhall forbear to go into farther detail of the practice in irrigation as adopted in Dorfetfhire.

There have been fome objections raifed againft irrigating by art, in the manner practifed in Gloucefter and Dorfetfhire; but I think thefe have been founded on a fuperficial view of the fubject, and I agree with Mr.

Mr. Wright in the arguments which he uſes to refute them. If it is ſaid that much land is wanted in cutting the drains, trenches, and mains, may it not be aſked, with propriety, if the land does not produce three times as much graſs as before; and if this is not to be conſidered among the moſt intereſting kinds of gain which can be added to annual income?

If it is ſaid to be expenſive; let me aſk, if the money thus ſunk in ameliorating the farm, does not return a better intereſt, and a more permanent one, than could have been obtained for the ſame ſum elſewhere?

If it is ſaid that the hay of theſe meadows is not ſo good as others; it may be replied, that *the beſt proof of a pudding lies in the eating*: for Mr. Wright aſſures us, that he has ſeen a cow, fatted wholly with this hay, which ſold for twenty pounds *.

Some again, it ſeems, have raiſed an objection to paying millers for the uſe of water. If this were a general caſe, it would apply with ſome degree of weight, but not inſurmountably. Mr. Wright gives as a

* Wright on the Water Meadow of Glouceſter, p. 14.

proof of this, that one meadow of ſixteen acres, in his pariſh, pays ſix guineas per annum to a miller for the uſe of his water; and if the proprietor did not find his account in it, he would certainly decline it. My plan for national irrigation, not only removes this objection totally, by taking water from lakes, ponds, and rivers, but goes to aſſiſt both the miller and navigable canals with ſurplus water; and may furniſh the irrigator with ſea water, containing ſalts in abundance.

If we are permitted, however, to credit the reſpectable clergyman who has communicated the Glouceſterſhire mode of irrigating, no man ever yet repented a fair experiment.

The Author of a work juſt publiſhed, under the title of the *New Farmer's Calendar, or Monthly Remembrancer*, a book which it is to be hoped will prove of ſome importance to practical farming, conſiders irrigation as a very excellent, though at the ſame time he ſays, an expenſive and frequently difficult mode of improvement: if the object of a farmer's care, however, is admitted, as in other occupations, to contemplate the greateſt and moſt ſpeedy accumulation of capital ſtock as its chief end, then expence will prove only a relative draw-

back

back upon a greater quantity of produce, which gives the cultivator an increafe of profit that he could not by any other means attain; and he will find himfelf poffeffed of all the benefits of overflow and depofited fediment, which the Remembrancer confeffes, without dreading thofe difficulties which judgment and perfeverance are competent to conquer.

Although this writer, as he acknowledges, has never paid much attention to the practice of irrigation, he has certainly hit upon fome of its beft principles, in applying it to the growth of the crop, or the amelioration of the foil: the chemical virtues which it imparts to the earth are doubtlefs to be admitted as a gratuitous manure, which might otherwife become wafted, or generate nuifance: and I heartily accord in his regret, that any fpring or river in his majefty's dominions are fuffered to wafte the moft material particles of nature's fructifying medium, when the various ftreams might be eafily diftributed to the refpective calls of irrigation, without depredating the ordinary properties of their pre-exifting functions. The Author of this Calendar eftimates the irrigation of an acre of meadow at a fum which would go far to

overturn my ſyſtem; yet it is the object of my ſyſtem to overturn his expence; and we may perhaps ultimately be both of us right in this ſeeming contradiction. An acre of meadow land, he ſays, will coſt from three to ſeven pounds to prepare it; that is, between three and ſeven, or an average of five pounds for each acre of a farm, I preſume, which an individual undertakes to irrigate, including command of water; and, conſequently, this expence muſt be repeated in the undertakings of each and every individual. Yet if the *nation* were to undertake a *ſyſtem of irrigation*, I apprehend the repetition of the heavieſt items may be avoided; and the beauties of Mr. Adam Smith's chapter on the diſtribution of labour would be aſtoniſhingly exemplified. The illuſtration which this Gentleman has choſen, by adopting a ſelect inſtance of improvement in Glouceſterſhire, will, in any event, add ſtrength to my propoſition, by the demonſtration of profit. On the 2d day of April, ſays he, 107 ſheep, 8 cows, and 7 colts, were fed on a piece of old watered meadow of eight acres, during five weeks; that is to ſay, until the time of ſhutting up for the hay crop, for the keep of which the propri-

etor

etor received £.35 1s. 10d. after the rate of 10d. a head per week for the ſheep, 3s. 6d. for the cows, and 4s. the colts. The crop of hay was afterwards about fifteen tons, which was ſix weeks in growing.

Such a profit as this, is, I apprehend, ſeldom drawn from commercial capital; yet it ſhould be remembered, that irrigation gave this as a ſpecimen of permanent production; not barely of rent, which, like commerce, might be uncertain, and ſubject to a fluctuation of proceeds according to the tide of fickle prejudice, or capricious opinion.

In caſes where permanency of ſituation, and durability of materials, are objects of moment, or where the preference and circumſtances of the party may juſtify a proportionate expence, the hydraulic machine, upon an improved *Noria* principle, which is now offered to the public by Meſſrs. Dixie and Mapleſtone, at their Factory in London, may be uſefully applied, and increaſed to any given ſize or capacity.

The one in daily uſe at their factory is forty feet elevation from the lower level to the bottom of the upper ciſtern; and, it is ſaid, it can raiſe one hundred gallons per minute

minute by one man's labour. The buckets are made of elm, fitted upon two ropes; so that one bucket serves as a cover to the other in their ascent: by which means, I conceive, they may not only be constructed so as to serve each other for lids, but the rotary movement they perform round the drum, pin, or spocket wheel avoids all but the lateral pressure of the atmosphere; which, comparatively considered, can scarce be admitted as friction. This method of avoiding any other resistance than the actual specific gravity, and its progressive accumulation with the increase of distance from the revolving axis, seems to fit this machine more particularly than the Spanish Noria, to many useful purposes, where a great elevation is demanded; though, perhaps, the cheapness of the Noria, and the capacity of many other cheap yet powerful machines that are now in use, have a preference, where only a small degree of ascent is required.

The cost of this machine is five shillings per foot running measure; say ten shillings per foot perpendicular height, besides extra charges, which may perhaps amount to between

tween ſix and ten guineas more for one of forty feet elevation.

In caſes where it may be convenient to uſe this machine for draining lands from a lower level to a higher, I apprehend the addition of a little expence in reſpect to a few feet elevation, may be conſidered economical; for by this means the water, which it becomes neceſſary to diſcharge, may be thrown into the buckets of an overſhot wheel without the expence of a dam; and, in mountainous countries, may be applied to an extent of machinery, and perhaps to a ſucceſſion of water-falls, without any extra expence in regard to a firſt moving power, which may thus be counted clear gain.

It is hence extremely obvious to me, that a very intereſting application of this apparatus may be made to many of the great mechanical and manufacturing purpoſes of Great Britain; and perhaps to thoſe of agricultural irrigation; the feeding of canals; and the watering of cities. There is one great uſe, however, which occurs to me, in which I think the more wealthy proprietors of houſes may profit by the adoption of it into their ſyſtem of houſehold economy. It has a capacity to ſpare all the cuſtomary

water

water carrying up ſtairs, becauſe, by the extenſion of its diſtributive pipes, the water may be more eaſily conducted into every room in the houſe by the labour of one man, than ten pails, perhaps one, full, can be carried up to the garrets.

In paying a juſt tribute to the merits of this profitable machine, we ſhould nevertheleſs remember that the idea is by no means new: Meſſrs. Dixie and Mapleſtone are too well inſtructed in their profeſſion, and too candid to invade the leſs improved merits of the Noria, or the more antient claims of Coſtar, who ſeems to have been the father of chain pumps, and the great grandfather of many improvements in the hydraulic art, which have ſucceſſively uſurped their patented ſtation in the pedigree of mechanic genius; and in the collateral application of his principles to ſolid operations.

The proprietors of this uſeful implement in its preſent improved condition ſeem to be contented with manufacturing it with buckets of wood, copper, pewter, or earthen ware, giving preference to pewter for its ſweetneſs and durability; and they recommend it for the deepeſt wells, mines, quar-

ries,

ries, coal pits, navigations, breweries, diſtilleries, &c. for which its rotary movement is particularly adapted.

In Switzerland, they have an invention ſimilar to this, which they apply to a pump by way of valves: a rope is reeved through the bore of the pump, which is left open at both ends; blocks of wood, of an oval figure, are threaded upon this rope in the manner of beads, and are confined to a particular ſpace from each other, by means of knots in the rope, which is formed into an endleſs ſtrap, paſſing round a drum wheel below the pump; and round a ſprocket wheel above it, this ſtrap pulls the blocks through the pump barrel, forcing the water before it. I have ſeen it in uſe in Spain, but the friction is great and diſorderly, and I think it better diſpenſed with.

Of Irrigation by means of Warping.

It is much to lamented, that in the present ſtate of agricultural ſcience, it is not eaſy for men in general to comprehend many local and technical terms belonging to huſbandry, which, properly ſpeaking, are fitting ſubjects for a Gloſſary. The reflections of the Board, it is to be hoped, will in due ſeaſon be awakened by this deficiency; and if their able Secretary could find time to form a more complete Agricultural Dictionary, progreſſively as words occur, in addition to thoſe which are already explained, it would probably be found capable of fixing a national ſtandard; and would prove a treaſure in huſbandry. A term offers on the ſubject I am at preſent about to notice, which may ſerve as an example: the word warping, which is technically applied to towing of ſhips, and preparing webs of cloth for the weaver's loom, is alſo, I find, applied in agriculture to deſcribe that ſpecies of irrigation which depoſits a quantity of ſediment from the flowing tide, and which forms a ſtratum

ſtratum of ſoil or manure when the waters have receded from it.

This definition of the word appears to be chiefly limited to tide water flowing from the ſea; though the nature of the accumulation ſeems to be nearly the ſame with the ſiltage of freſh-water rivers, the redundancy of which, by way of diſtinction, is called flooding.

This operation, whereby ſoil is created, is ſaid to have originated within a few years of the preſent time; and various counties in England lay claim to the diſcovery, without any degree of acknowledgment to the tuition of Egyptian huſbandry. A late work, entitled the Remembrancer, or Farmer's Calendar, attributes the primary practice to the county of Lincoln, while others beſtow the laurels on the county of York: but all ſeem to agree, that although the works are, in the firſt inſtance, expenſive, there are few, if any, caſes where money can be more advantageouſly laid out.

The fertility of the Nile affords a ſtimulus to exertion, which ſhould be ever preſent before the warper; and I avail myſelf of a few Britiſh examples which Sir John Sinclair has kindly ſuggeſted to me, for the purpoſe of

of rendering this discovery more generally known.

The practice of warping, although one of the most important improvements in husbandry, is so local, so limited in its extent, and so partially understood, that I shall need no apology for dwelling at some length upon the subject: so far, indeed, as examples have occurred through this reference, or in the surveys reported to the Board of Agriculture, I must beg the popular indulgence, and avail myself of the means which are to be obtained for rendering my book more distributively useful in agricultural experiments and practice.

Whether this inestimable science owes its birth to the inundations of Egypt, or to more modern discoveries, is, perhaps, a question of some doubt; so far as the practice has become known and propagated under the term by which it is designated in this country, England, it is even doubtful. The West Riding of Yorkshire, we find, lays claim to its originality; though the nature of the fens in Lincolnshire and Cambridge seems to indicate an equal pretension on their parts. In either case it is obvious that the richest kind of superstratum is created by it; and

and the Agricultural Surveys, where this ſpecies of improvement has been noticed, are in uniſon to ſupport this more eſſential concluſion.

The method recommended by Lord Hawke* is, to bank the land, which is to be warped, againſt the river; ſloping the banks on each ſide of their crown or top, at the rate of three feet to every one foot perpendicular riſe. The height and breadth of the top will, of courſe, be regulated by the ſtrength of the tide and depth of the water; for the object is to command the land and water at pleaſure. The openings or ſluices in the banks are a ſmaller or greater number, according with the extent of the land to be warped, and the fancy of the proprietor; but, in general, there are only two ſluices; one called the *floodgate*, to admit; and the other called the *clough*, to let off the water gently. Theſe, Lord Hawke ſays, are enough for ten or fifteen acres.

"When the ſpring tide begins to ebb," ſays his Lordſhip, "the floodgate is opened to admit the tide, the clough having been previouſly ſhut by the weight of water

* See Agricultural Survey of Yorkſhire (W. R.) p. 164.

brought up the river by the flow of the tide. As the tide ebbs down the river, the weight or preſſure of water being taken from the outſide of the clough next the river, the tide-water that has been previouſly admitted by the floodgate opens the clough again, and diſcharges itſelf ſlowly but completely thro' it. The cloughs are ſo conſtructed as to let the water run off, between the ebb of the tide admitted, and the flow of the next; and to this point particular attention is paid. The floodgates are placed ſo high as only to let in the ſpring-tides when opened: they are placed above the level of the common tides."

We learn, alſo, from his Lordſhip's account that it is cuſtomary to plant willows *in front* of the banks as a protection; but not *on* the banks, becauſe this would give the wind a ſufficient power to ſhake and injure them.

Lands ſituated like thoſe at Radcliffe, *beneath the level of the ſpring-tides*, appear to be the moſt ſuitable for warping; although it is the practice to warp thoſe of other deſcriptions, and to warp one year in ſeven, which is deemed ſufficient.

Lord Hawke mentions an inſtance of a field

field of *good-for-nothing* corn land, which was raiſed to fourteen inches of warp in three years, and then ſowed with beans. From this crop he expected eight quarters. The warp conſiſts of the mud and ſalts which the ebbing tide depoſits; and this is more or leſs according to the diſtance from the Humber. Near Howden, ſays my Lord, one tide will depoſit an inch of mud. "Cherry Cob Sands," ſays he, "were gained from the Humber by warping; they are ſuppoſed to be four yards thick of warp at leaſt; ſome of thoſe were ploughed for twelve, fourteen, or ſixteen years, before they would grow graſs ſeeds. The land," ſays he, "muſt be in tillage for ſome conſiderable time after warping—for ſix years at leaſt. The land, if laid down to graſs, and continued in graſs, is not warped; for the ſalts in the mud would infallibly kill the graſs ſeeds. When it is propoſed to ſow the land again with corn, then the land is warped; when they find the graſs decline, then they warp and plough it out. As the land varies in quality, ſo does the time in which it will produce good graſs: the land is never fallowed but in the year when it is warped."

*Mr. Day, of Doncaſter, conceives the practice of warping in the low part of the weſt riding of Yorkſhire, to have originated from the tides overflowing the banks of the river, and depoſiting a ſediment which was found to produce luxuriant crops of corn. A farmer, it ſeems, gained light on the ſubject from this caſualty; and obtained leave to lay a tunnel of a few inches ſquare through the embankments of Hatfield Chace, for the purpoſe of warping his lands, on giving a ſatisfactory ſecurity in regard to the conſequences of his undertaking. It is ſaid, by this gentleman, that warping has only been ſpreading its beneficial influence by *artificial* practice, in this country, about twenty or twenty-five years. It is to be hoped, however, that the intereſting advantages we ſhall be enabled to exemplify in this book, will contribute ſpeedily to extend this very profitable acquiſition towards the extermination of ſcarcity.

Mr. Day conſiders the expence of warping to be influenced greatly by the ſituation of the lands, and the courſe and diſtance which the warp is to be conducted. He

* Ag. Rep. W. R. Yorkſhire, p. 166.

ſays,

ſays, " 1ſt, The ſituation of the lands is to be conſidered. 2dly, The quantity of land the ſame drains and cloughs will be ſufficient to warp. 3dly, The expence of building the cloughs, cutting the drains, embanking the lands, &c. An eſtimate of which expence being made, then it will be neceſſary to know the number of acres ſuch cloughs and drains will warp, before any eſtimate per acre can be made."

It is thus clear, that the expence of warping per acre will depend greatly on the extent of land which may be overflowed by one and the ſame ſet of drains and cloughs. Mr. Day thinks that great quantities of land in the country might be warped at ſo ſmall an expence as from four to eight pounds per acre; and he ſtates the advantages gained at various rates, from five to fifty pounds per acre; and conſiders the greateſt advantage to ariſe from warping the worſt and moſt porous land *.

In enumerating the advantages that accrue from warping, this gentleman ſays the land will bring very large crops for ſeveral years afterwards without any further manure; and

* Ag. Survey York. W. R. p. 168.

that warping may be eaſily repeated at a ſmall expence by opening the old drains, which may ſerve in the interim for draining the land if it ſhould be neceſſary. He recommends the culture of oats for the firſt crop after warping; and thinks this practice better adapted to oats, wheat, or beans, than to barley; which laſt is rendered too ſtrong and coarſe by the great fertility of the ſoil. He recommends, however, a coat of warp whenever the land is fallowed; and conſiders this management, above all other kinds; the cheapeſt, when properly applied.

Mr. Day defines *warp* to be the ſediment left upon the land by flooding it with *tide* water. It ſeems to be the letting in water where the tide flows that is termed *warping*; letting in freſh water from a river, though by a ſimilar operation, would be called *flooding*, and not *warping*. The benefit derived from warp appears to reſt in the ſaline particles, and a greater depoſit of ſediment than can be generally obtained from freſh water floodings. He recommends June, July, and Auguſt, as the beſt months for warping; becauſe, at this ſeaſon the ſoil is in its dryeſt ſtate, and of courſe the moſt ſuſceptible of thoſe impregnations and ac-

quiſitions

quiſitions which are received in the acts of abſorption and adheſion. He conſiders wet ſeaſons the leaſt proper for warping; becauſe the redundancy of freſh water, which becomes mixed with the muddy tide muſt neceſſarily weaken the ſaturation, and render it leſs capable of depoſiting ſediment. Land thus manured is deemed to be the beſt for potatoes, and far the moſt productive.

The depth of the water to be uſed for warping, will vary according to the ſurface of the ſoil; nor is it material that it ſhould be always at the ſame height, although it is well to retain a depth of three or four feet where the ſituation and embankments will admit of it. Mr. Day attributes the firſt experiment in warping to Mr. Richard Jennings, of Armin near Howden, about fifty years ago. It was next attempted, he ſays, by a Mr. Farham, ſteward to a Mr. Twiſleton of Rawcliffe; and by a Mr. Mould, of Potter Grange, about forty years ago; ſince when it has been gaining ground in practice. I merely mention theſe particulars as a reference to claims for the honour of this uſeful diſcovery, without any deſign to change the ground on which I find the various pretenſions.

The Secretary to the Board of Agriculture has paid minute attention to the ſubject of warping in the County of Lincoln; and ſpeaks of it as one of the moſt ſingular and intereſting improvements in huſbandry which he has any where heard of*.

"The water of the tides that come up the Trent, Ouze, Dun, and other rivers," ſays he, "which empty themſelves into the great eſtuary of the Humber, is muddy to an exceſs; in ſo much, that in ſummer if a cylindrical glaſs, twelve or fifteen inches long, be filled with it, it will preſently depoſit an inch, and ſometimes more, of what is called *warp*. †Where it comes from, is a diſpute.

* See Ag. Surv. of Lincoln, p. 216.

† A ſimilar queſtion ſuggeſted itſelf to my mind a year or two ago, on obſerving the accumulation of ſilt in the Ouſe, and other rivers of the fen countries, ſince the period of the Roman poſſeſſions there, as repreſented in the looſe exiſting documents concerning drainage. It appears to me to be a matter of importance to the engineering of that country, to aſcertain the preciſe points of deep water outfall into the North Sea; and to trace, as far as practicable, the exact tendency of the *undertow* channel, even to the fartheſt extent of ſoundings: for it would ſeem to be a fruitleſs operation to repeat a ſyſtem of error, which drains one man's land to drown another's; and which will for ever be the caſe while a mere

diſpute. The Humber, at its mouth, is clear water; and no floods in the countries waſhed by the warp rivers bring it, but, on the contrary, do much miſchief by ſpoiling the warp.

In

mere ſurface-view of the ſubject is palmed upon the parties concerned, for profeſſional knowledge. An inveſtigation of the *reports* on this particular, when made by men of ſcience, will eaſily diſcover the *fortunate* man to whoſe *popular* opinion I allude; I truſt the very honourable profeſſion of engineers, to ſeveral of whom I am now perſonally known, will not think me ſo illiberal as to hint at any *general* reflection. To return however to the *point*, I have often been perſuaded that the extreme degree of ſiltage which theſe rivers admit, owes its exiſtence to a cauſe ſo far back, that it muſt for ever hinge on conjecture. The ſections of the land on the coaſt of France and England, as well as the intermediate ſoundings, and the action of the tides upon the part called the *Rip Raps*, (from the motion which the meeting of the waters occaſions), indicate very ſtrongly, I think, that the period once exiſted when the countries of France and England formed one land; and the channel itſelf was no more than a river. However ſurpriſing it may be thought, at firſt view, that ſuch an aſtoniſhing convulſion of nature ſhould have happened, as that which muſt have been required to rend and ſeparate ſuch a vaſt body of earth, and to ſcatter it about in the North Sea, from whence the continual friction of the tides muſt have been gradually ſhifting it about for many thouſand years, it is not

In the very drieſt ſeaſons, and longeſt droughts, it is beſt and moſt plentiful. The improvement is perfectly ſimple, and conſiſts in nothing more than letting in the tide

not wholly improbable or without corroborating examples which are better known to us.

The remains of the *Godwin Sands* are a *diſcernable* ſubject; and records afford a more diſtant knowledge of their hiſtory.

Chartley-moor, in Lancaſhire, according to *Leland*, Vol. VII. p. 49. (See Lancaſter Surv. p. 105.) was the ſubject of an extraordinary convulſion in former days; and the hiſtorical account informs us, that not only a part of that tract of land was precipitated into the river Merſy, but that it was alſo diſtributed along the ſhores of Wales, the Iſle of Man, and even ſome of it into Ireland. A ſimilar breach, on this ſmall ſcale of extraordinary events, happened many years ago at Daggenham, upon the river Thames; and there are many other inſtances in Great Britain.

In the year 1782, I was myſelf on board a veſſel then cruiſing along the American coaſt, at a place called *Harvey's Quarters*, not far from the mouth of Little Egg-harbour river; and, in viewing ſeveral wrecks which were viſible at low water, a Mr. Willis, then on board, aſſured me, that, within thirty years before that time, he had purchaſed mellons of Mr. Harvey's negroes, who then reſided at that eſtate, which was a conſiderable tract of land: at preſent the ſhoals formed by its remains extend far from the ſhores of the main land.

I think

tide at high water, to depoſit the warp, and permitting it to run off again as the tide falls; this is the aim and effect. But to render it efficacious, the water muſt be at command, to keep it out and let it in at pleaſure; ſo that there muſt not only be a cut or canal made to join the river, but a ſluice at the mouth to open or ſhut as wanted; and that the water may be of a proper depth on the

I think whoever has been among the Bahama Iſlands will agree with me, that there are viſible traces there of a country, which has been formerly united with the American continent.

The traditions of the Seminola Indians aſſert, that it is not many generations back that their anceſtors croſſed the Gulph of Mexico, in canoes, to the Iſland of Cuba. This ſeems to have been equally probable in reſpect to the Grand Bank of Bahama, which ſeems not to be leſs practicable; and there are alſo very probable proofs, even yet to be ſeen, which induce a rational ſuppoſition, that the whole Weſt-India Iſlands formed a part of the weſtern terra firma. To men of ſcience I dare yet be farther bold by putting the queſtion, whether, in conſidering the current of the Gulph-ſtream, and the viſible iſlands, rocks, and ſoundings, which pourtray the line of terrene affinity acroſs the Atlantic Ocean, from the banks of Newfoundland to the Canarian coaſts of Africa, ſtill more important philoſophical queſtions are not ſuggeſted?

W. T.

land

land to be warped, and alſo prevented flowing over contiguous lands, whether cultivated or not, banks are raiſed around the fields to be warped, from three or four to ſix or ſeven feet high, according to circumſtances. Thus, if the tract is large, the canal which takes the water, and which, as in irrigation, might be called the grand *carrier*, may be made ſeveral miles long; it has been tried as far as *four*, ſo as to warp the lands on each ſide the whole way; and lateral cuts may be made in any direction for the ſame purpoſe, obſerving, however, that the effect leſſens as you recede from the river; that is, it demands longer time to depoſit warp enough. But the effect is very different from that of *irrigation* *; for it is not the water that works the effect, but the mud, ſo that in floods the buſineſs ceaſes, and alſo in winter; and it is not to manure the ſoil, but to create it †.

What the land is, intended to be warped, is not of the ſmalleſt conſequence; a bog, clay, ſand, peat, or a barn floor—all one: as

* I diſtinguiſh this *ſimple* irrigation. W. T.

† I ſhould call ploughing, for the purpoſe of burying or turning in a ſediment thus depoſited, a manuring by means of compound irrigation. W. T.

the

the warp raiſes it in one ſummer from ſix to ſixteen inches thick; and in hollows, or low places, two, three, or four feet, ſo as to leave the whole piece level.

Thus a ſoil of any depth you pleaſe is formed, which conſiſts of mud of a vaſt fertility, though containing not much beſides ſand; but a ſand unique.

Mr. Dalton, of Knaith, ſent ſome to an eminent chemiſt; whoſe report was, that it contains mucilage, and a very minute portion of ſaline matter; a conſiderable one of calcareous earth; the reſidue is mica and ſand; the latter in far the largeſt quantity; both in very fine particles. Here is no mention of any thing argillaceous; but from examining in the fields much warp, I am clear there muſt be clay in the ſame, from its caking in ſmall clods, and from its cleanſing cloth of greaſe almoſt like fuller's earth.

A conſiderable warp-farmer told me, that the ſtiffer warp was the beſt; but in general it has the appearance of ſand, and all glitters with micaceous particles.

So much, in general, as to the effect: the culture, crops, &c. are circumſtances that will beſt appear, with others, in the following notes taken on the ſpot.

The

The firſt warping works which I viewed were at Morton Ferry, where Mr. Harriſon, who ſhewed me them, has a large concern in a very great undertaking, no leſs than to warp 4620 acres of commons, by means of an act of incloſure and drainage. They are attempting to warp four hundred acres in one piece, which is to be ſold to pay the expence of doing all the reſt, and they have been offered 30s. an acre rent for it, when finiſhed: a double ſluice is erected to take the water from the Trent, which coſt 1200l. and a double canal, cut under the idea that water ſhould come in by one, and return by another; this apparently has created a great expence.

They have uſed fifteen tides over 200 acres, which has raiſed about ſix inches of warp in ſome places, but not uniform: and the opinion of the beſt informed perſons is, that they muſt divide it into fifty-acred pieces, and do one at a time. All this may be eaſily corrected, and the improvement will be amazingly great. The common is worth nothing, as it has been hitherto fed.

This ſtatement by the Secretary of the Board of Agriculture is followed by an official report and eſtimate concerning the premiſes;

premiſes; and by many other intereſting notes. From theſe, I ſhall ſelect ſuch particulars as promiſe an advantageous reſult through this preſent medium of diſtribution.

The whole quantity of waſte land incloſed, appears, as before ſtated by Mr. Young, to be 4260 acres by actual ſurvey, 2600 acres of which is low land capable of being warped; the remaining 1660 acres high land.

The ſurface is a very level one, but admits of a ſufficient fall for competent drainage. Two appertures of eight feet wide, and ten feet high, each, are recommended for the warping-ſluices of this undertaking. The warping drains to be 18 feet wide at bottom, 26 feet at top, and 4 feet deep; and to have a foreland of 4 feet, with banks on each ſide of 14 feet baſe, 6 feet top, and 5 feet high each.

Another drain, in theſe works, to be 24 feet bottom, 32 feet top, and 4 feet deep, with forelands, &c. as aforeſaid: this drain leads to the *outfall*. Three ſluices, of 10 by 8 feet, are appropriated to the uſe of the three drains which diſcharge at this point; and

and the sluices are laid 2 feet lower than low-water mark. The following, as reported, is an

Estimate of the Expence.

	£.	s.	d.
Cutting the catch-water drain, 400 chains, or 3696 *floors* of earth, at 3s. each -	554	8	0
Cutting a main-drain, or warping-drain, 258 chains, or 3746 floors, at 4s. each - -	749	1	0
Cutting a main or warping-drain, $276\frac{1}{2}$ chains, or 4015 floors, at 4s. each - - -	803	0	0
Cutting a main-drain, 100 chains, or 1848 floors of earth, at 4s. per floor - - -	369	3	0
Warping-sluice near Morton	400	0	0
Ditto, near Walkerith -	400	0	0
Outfall ditto near Ravenfleet -	600	0	0
Carried forward,	£.3875	12	0

Amount

	£.	s.	d.
Amount brought forward,	3875	12	0
Road-bridge near Morton -	150	0	0
Ditto at Swanfea Bridge -	180	0	0
Two culvers under the warping-drains, at 100l. each - -	200	0	0
	4405	12	0
Contingencies, 10 per cent.	440	10	0
Total	£4846	2	0

Various valuable examples here follow on the fame authority.

At Althorpe 300 acres are improving from an inferior ftate to 30s. per acre. At Knaith an experiment afcertains warp to be equal to dung. Similar undertakings at Amcots. At Gainfborough a fpot was warped to the depth of 10 inches in eight hours. When a bank breaks in warping works upon the Trent, they furround the fpot with a new femi-circular bank, in order to let in the warp, which fills it up prefently.

The improvements by warping, which Mr. Webfter has made at Bankfide, (which is within the county of York) merit particu-

lar attention. His farm contains 212 acres of land, all warped. It coft him 11l. per acre, and he would not now take 70l. for it. He thinks it worth 80l. per acre generally, and fome parts worth 100l. The whole expences of his improvements did not exceed 2,500l. or 12l. per acre. A neighbour below him offers 5l. per acre for the ufe of his fluice and main cut to warp 300 acres; which amounts to 1,500l. and reduces the expence of Mr. Webfter's works to 1000l. Take it, however, at the higheft, and fay that the land coft 11l. and the improvements 12l. per acre, making 23l. and he will gain, by a fale at 70l. per acre, 47l. per acre, or 9,964l. upon the operation.

The depths warped, in this inftance, in four years, were 18 inches, 2 feet, 2½ feet, &c. This Gentleman has warped fome land which, before warping, was moor land, worth only 18d. per acre; but it is now as good as the beft: fome of it would let at 5l. per acre for flax and potatoes; and the whole at 50s. He has 20 acres that was warped 3 feet deep, between the beginning of June and end of September; and 18 acres, part whereof is 3½ feet deep of warp.

This

This Gentleman has alſo applied warping on ſtubbles in autumn, by way of manuring. The crops have been very great; of potatoes, from 80 to 130 tubs per acre; each tub meaſuring 36 gallons, and ſelling at 3s. to 3s. 6d. per tub for the round kind; and at 5s. to 8s. per tub for the kidneys: this, at the preſent price, May, 1800, at 2d. per pound in London, would be an enormous product.

* Twenty acres, warped by this Gentleman in 1794, could not be ploughed for oats in 1795; he therefore ſowed the oats on the freſh warp, and ſcuffled in the ſeed by men drawing a ſcuffler, allowing nine men to a ſcuffle: three acres of this, meaſured ſeparately, afforded 14 quarters 1 ſack per acre. I very much doubt that the boaſted crops of Kentuckie have exceeded this.

Mr. Webſter alſo warped 12 acres of wheat ſtubble, and ſowed it with oats, in April, which produced 12 quarters per acre: then wheat, 36 buſhels per acre; never leſs than 30 buſhels per acre.

Six acres of beans, ſays Mr. Young, produced 30 loads per acre, or 90 buſhels; and one acre, meaſured for a wager, went 9

* See Survey of Lincoln, p. 283.

bushels over this. These lands have produced 144 pods from one bean on four stalks; and Tartarian oats 7 feet high. One piece warped in 1793, produced oats in 1794, at the rate of 6 quarters per acre: white clover and hay seed were sown with them, mown twice the first year; the first cutting yielded 3 tons of hay per acre; the second 1 ton; and after that an immense eddish.

The great beauty of this species of improvement seems to consist, not only in the capacity for creating soil altogether, but also in the ease with which land can always be reinstated or refreshed at small expence. Flax produces on warp lands 40 to 50 stone per acre.

A sluice for warping, 5 feet high, and 7 feet wide, will warp 50 acres per annum; and perhaps 70 acres, if the land lies well, and near the river. The costs will be from 400l. to 500l.

Warped lands, at Reeveness, has sold for 100l. per acre. Lord Beverley has six or seven sluices going, and has warped 300 acres in a year.

Twenty-four thousand pounds was, some time past, expended in making a canal from the river Trent, near Althorpe, to Thorne,

&c.

&c. This is a navigable canal of 40 feet bottom, and deſigned for warping a vaſt extent of country. A branch to Crowle is laid out; and another from Thorne to the river Dun: theſe are for navigation; and on each ſide of the navigable canals are ſokage drains for relieving the overflowing waters of the country, and at other times admitting tide water for the proceſs of warping. It is propoſed to make cuts of twelve miles, at right angles, for the purpoſe of ſelling warp to the country, and for delivering through ſluices on either ſide, as occaſion requires. The price propoſed is from 4 to 5 pounds per acre; and proviſion againſt ſiltage of the works, &c. is made ſo that the ſokage drains can be ſcoured or ſupplied by means of ſluices from the navigable canal.

* Mr. Nicholſon, of Rawcliffe, (which is alſo in Yorkſhire) takes the levels firſt, and builds a ſluice. If he has to convey the warp the diſtance of a quarter or half a mile, ſixty acres may be done the firſt year; but the drier the ſeaſon the better. The clough or ſluice, &c. is 8 feet wide, and 5 or 6 feet high. Drains 14 feet at bottom, and as

* See Agricul. Survey of Lincoln, p. 284.

much more at top. Banks are 4 to 8 feet high. He begins at Lady-day, and continues till Martinmas. Three inches of warp will produce great crops, and they will be as good at ſix inches as at ſix feet. Warp is cold, and, if deep, takes time: a dry year is the beſt. Crops ought to be, beans 20 loads; wheat 10 or 12 loads; oats 10 quarters; never barley: after ſix years, potatoes and good flax. Mr. Nicholſon makes it worth 40 or 50l. per acre. By keeping up the ſluices and drains, land can always be refreſhed at any time. Crops of flax on this kind of land have been ſold at 10l. per acre ſtanding; it is afterwards ſown in rape. Theſe lands Mr. Nicholſon had warped to a level, on a ſlope gradually accumulating warp from the depth of two feet to ſix inches.

At Snaith ſand land for the plough has ſold at 100l. per acre.

Warp is ſaid to leave an eighth of an inch every tide: hence we have a datum for regular calculation; and, if we take away the ſediment which is depoſited, for the purpoſe of manuring the higher lands, we may eaſily eſtimate the time when the tides will re-

inſtate

inſtate the warp, and add ſo much clear gain to the quality of the upland eſtate.

Warp is ſaid to be left on the premiſes in diſtinct and ſeparate flakes, not in one conſolidated maſs; the water ſhould be made to run perfectly off, that the warp may incruſt; and this cannot be the caſe if much water is ſuffered to remain in the drains: thus, where there is only one ſluice, it can only be uſed every other tide.

On the ſea coaſt, from Wiſbeach to Boſton, there is much ſilt or warp; and ſome experiments have been tried by Major Cartwright and others, which ought, from their favourable reſult, to ſtimulate farmers to carting or boating this kind of manure to their upland farms, where they have not the means of irrigating in the uſual method, and can procure the warp within a practicable diſtance.

Much, in this reſpect, muſt nevertheleſs depend on the combination of circumſtances which the landlord facilitates by interweaving his own intereſt in the web of his cultivator's proſperity.

To what extent this ineſtimable improvement will be extended in the courſe of a few years, it is not eaſy to determine. An ex-

 tenſive

tenſive field is left open for it in the fens of Lincolnſhire, the Bedford levels, and the adjacent country; and it reſts with land proprietors in thoſe parts to benefit themſelves, by enabling others to better their condition in the enterprize. If this is not done, while the accepted day is preſent, we may venture to predict that more favoured countries will become competitors for agricultural ſuperiority; for there can be no doubt that the enterprizing genius of the preſent generation will anticipate the future advantages which Britiſh experiments have brought to light in countries whoſe fertility and expanſe is by no means inferior to the warpings of the Humber, or the fructifying inundations of the recently explored territories of Egypt.

PUTRID WATER FROM THE STEEPING OF FLAX, HEMP, &c.

(Taken from the 26th §. XV. Chapter, proposed Rep. from the Board of Agriculture.) 1795.

It is ſtated in a very valuable Report laid before the Board *, that the land on which flax was ſpread for dying, after being ſteeped in water, being greatly improved thereby, coarſe and ſour paſture being changed into the beſt ſort of graſſes, and into ſweet herbage, Mr. Billingſly was thence induced to apply it to paſture land by means of carts, ſimilar to thoſe uſed near London for watering the roads. The effect was aſtoniſhing, and advanced the land in value from 10l. to 50l. per acre. This liquid, he ſuppoſes, is much ſuperior to animal urine; and it is earneſtly recommended to the attention of thoſe who cultivate hemp or flax.

In Lincolnſhire, where this branch of huſbandry has been much attended to, they

* Somerſet Report.

find

find the ſediment of the pits, in which flax or hemp have been ſteeped, a very valuable manure; and, conſidering theſe circumſtances, it would appear that an idea commonly circulated, that flax and hemp ought not to be cultivated in this country, becauſe they are exhauſting crops, and return nothing to the ſoil, is not perfectly well founded. It has not yet been aſcertained to what extent manure from an acre of flax can be obtained, but it is probably conſiderable.

The circumſtance above alluded to naturally leads to the following obſervations:

1. It is well known that flax will grow in almoſt any part of the country, however elevated. In conſequence of the rapidity with which it grows, and the ſhort time neceſſary for its remaining in the ground, it is hardly ever injured by froſt. If, therefore, any quantity of flax were raiſed in the higher parts of our mountainous diſtricts, and was kept in ponds or reſervoirs of water there, the water might thus be converted into a uſeful manure; and irrigating the land below might convert it into excellent paſture.

2. The ſecond obſervation is, that improving water as a manure has been much leſs attended to than it probably deſerves.

To

To make it fit for that purpofe, nothing more is neceffary than to render it putrid. From its being in a liquid ftate, it feems to be better adapted for being brought into a putrefcent ftate than earth, and other fubftances of a more compact and clofer nature. If any chemift could difcover a mode of quickly rendering a confiderable quantity of water putrid, at a fmall expence, he will probably do more for the improvement of agriculture, than could poffibly be effected by almoft any other difcovery.

The moft likely mode is to collect it into pools, render it ftagnant, and put green vegetable fubftances in it: this will produce putridity in the fpace of a few days.

To the above account the following is fubjoined: putrid water, it would appear, muft poffefs the fingular property of extirpating that part of the grameneous tribe which are adverfe to the purpofes of the grazier and farmer, or of changing (as here ftated) the coarfe and four graffes into that fweet herbage agreeable to his wifhes. This quality of water will certainly be worth attending to. In Devonfhire water is meliorated by lime in ponds, there known under the name of *prefidents*; which are ponds enriched by the

drain

drain of an adjoining *linhay*, or yard, with the addition of a bag of lime at different times.

The author of the present work begs leave to add, that he saw in 1790, at a villa belonging to William Alexander, Esq. near Richmond, in Virginia, a pool constructed in the center of a new garden, in a poor sandy soil, into which the water was conveyed by pipes: these pipes communicated to a pump erected in a house at the end of the garden, wherein all vegetables gathered for the table were prepared by the gardener, who was a Frenchman. A cistern, with holes in the bottom, was placed beneath the spout of the pump, so that when the vegetables were put into it to be washed by pumping the water, the foul water and filth was immediately conducted into the putrescent reservoir in the center, from whence the garden was watered. On enquiring of the gardener why he did not distribute the pure water immediately from the pump? He answered, that no water was fit for a garden until it had been exposed to the sun and to the effects of putrefaction. Hence it may be supposed that this practice is common in some parts of France.

IRRIGATION IN THE DISTRICT OF WILTSHIRE, AS COMMUNICATED TO THE BOARD OF AGRICULTURE IN THE WILTSHIRE REPORT.

There is perhaps no part of this kingdom where the ſyſtem of watering meadows is ſo well underſtood, and carried to ſo great perfection, as in this diſtrict. This, which is ſo juſtly called, *by Mr. Kent*, "the greateſt and moſt valuable of all improvements," was generally introduced into this diſtrict in the latter end of the laſt and the beginning of this century. Many of the moſt valuable and beſt formed meadows, particularly in the *Wyley Bourn*, were made under the directions of one farmer Baverſtock, of Stockton, between the year 1700, and 1705. And at preſent there is ſcarcely a river or brook in the diſtrict that is not applied in ſome way or other to this purpoſe.

An imperfect ſcheme of watering had, undoubtedly been practiſed before that period. Perhaps, indeed, its introduction into this diſtrict

diſtrict is almoſt co-eval with that of folding ſheep, with which it is intimately connected: but the *regular mode*, in which both ſyſtems are now conducted, is certainly not very ancient. Many old farmers, who have died within the memory of man, remembered when neither of the ſyſtems was conducted on any regular plan.

The Theory of Water-meadows.

The idea of watering meadows, ſo far as it relates to bringing the water upon the land, was taken from nature. It muſt have been always obſerved, that winter-floods produced fertility, provided the water did not remain *too long* on the land.

The idea of taking the water *off* the land *at will*, and bringing it *on again at will*, is the effect of art; and the knowledge of the proper time to do this, is the effect of obſervation.

A water-meadow is a *hot-bed* for graſs. In what manner water acts upon the land, ſo as to produce a premature vegetation, before

before natural vegetation begins, is a philofophical problem, which it is not a farmer's province to folve.—It was fufficient for him to know that the fact was fo. Obfervation on the effects of water, fo brought on, foon fhewed him at what period its good effects ceafed, and when it began to do mifchief. This obfervation, therefore, regulated the time of keeping the water on the land; and as this period was different on different kinds of land, and at different feafons of the year, it became neceffary that they fhould have fuch a command of water, as to take it off immediately as foon as they found the ftate of the land required it. This, by degrees, produced that regular difpofition of the water-carriages, and water-drains, which in a well laid out meadow, bring on and carry off the water as fyftematically as the arteries and veins do the blood in the human body.

As water-meadows are totally unknown in many parts of the kingdom, and but very partially known in others, it may not be thought improper, in the agricultural account of South Wiltfhire, to fpeak a little more fully on their nature and properties. If it fhould tend to excite the fame improvement

ment in other counties, one of the great objects of the Board of Agriculture will be attained.

The Nature and Properties of Water-meadows.

It has been already premiſed, that the principal contrivance of a water-meadow is the power of bringing on and carrying off the water at pleaſure. And provided this great object can be accompliſhed, it is not material what the ſhape of a water-meadow is, or that the diſpoſition of the trenches, technically *the works of the meadows*, ſhould be uniform.

But as very little land can be entirely commanded by water, unleſs its inequalities are reduced by manual labour, it has been found convenient to adopt two different kinds of water-meadows, one for land lying on declivities, and which muſt in general be watered from ſprings or ſmall brooks; and the other for low land rivers, to be watered from thoſe rivers.

The

The firſt kind is called in Wiltſhire, "*catch-work meadows;*" and the latter, "*flowing meadows.*" The latter are by far the moſt general in this diſtrict.

It is impoſſible to give any fully-intelligible written deſcription of the mode of making theſe meadows: this operation muſt be ſeen, to be properly underſtood.

Catch-work Meadows deſcribed.

But to elucidate the diſtinction between the two kinds of meadows, and to give ſome idea what are the ſituations in which they may be introduced, it may be neceſſary to remark, that the catch-work meadows* are made by turning a ſpring, or ſmall ſtream, along the ſide of a hill, and thereby watering the land between the new cut, or, as it is provincially called, the main-carriage, and the original water-courſe, which now

* The "catch-work meadows," are the kind that are ſo common on the ſides of the hills in Devonſhire; and are partly deſcribed by plates under the Glouceſterſhire head.

becomes the main-drain. This is ſometimes done in particular inſtances, merely by making the main-cut level, and ſtopping it at the end; ſo that when it is full, the water may run out at the ſide, and flood the land below it. But as the water would ſoon ceaſe to run *equally* for any great length, and would waſh the land out in gutters, it has been found neceſſary to cut ſmall parallel trenches, or carriages, at diſtances of twenty or thirty feet, to catch the water again; and each of theſe being likewiſe ſtopped at its end, lets the water over its ſide, and diſtributes it until it is caught by the next, and ſo on over all the intermediate beds to the main-drain at the bottom of the meadow; which receives the water, and carries it on to water another meadow below; or, if it can be ſo contrived, another part of the ſame meadow on a lower level.

To draw the water out of theſe parallel trenches, or carriages, and lay the intermediate beds dry, a narrow deep drain croſſes them at right angles, at about every nine or ten poles length, and leads from the main-carriage at top, to the main-drain at the bottom of the meadow.

When

When this meadow is to be watered, the ends of the carriages adjoining the croſs-drains, are ſtopt with turf dug on the ſpot, and the water is thrown over as much of the meadow as it will cover well at a time, which the watermen call a *pitch of work*; and when it is neceſſary to lay this pitch dry, they take out the turves, and let the water into the drains, and proceed to water another pitch.

This kind of water-meadows is ſeldom expenſive: the ſtream of water being uſually ſmall and manageable, few hatches are neceſſary; and, the lands lying on a declivity, much leſs manual labour is required to throw the water over it regularly, and particularly *to get it off again*, than in the flowing meadows. The expence of making ſuch a meadow is uſually from three to five pounds per acre; the improvement frequently from fifteen ſhillings an acre, to at leaſt forty, per annum.

The annual expence of keeping up the works, and watering the meadow, which is uſually done by the acre, ſeldom ſo high as 7s. 6d. per acre.

Flowing-meadows deſcribed.

The other kind of water-meadows, *viz.* thoſe uſually called *flowing-meadows*, require much more labour and ſyſtem in their formation. The land applicable to this purpoſe being frequently a flat moraſs, the firſt object to be conſidered is, how the water is to be *got off* when once brought on; and in ſuch ſituations this can ſeldom be done without throwing up the land in high ridges, with deep drains between them. A main-carriage being then taken out of the river at a higher level, ſo as to command the tops of theſe ridges, the water is carried by ſmall trenches or carriages along the top of each ridge, and by means of moveable ſtops of earth is thrown over on each ſide, and received in the drain below, from whence it is collected into a main-drain, and carried on to water other meadows, or other parts of the ſame meadow below. One tier of theſe ridges being uſually watered at once, is called "*a pitch of work*;" and it is cuſtomary to make the ridges thirty or forty feet wide,

or,

or, if the water is abundant, perhaps ſixty feet, and nine or ten poles in length, or larger, according to the ſtrength and plenty of water.

It is obvious, from this deſcription, that as the water in this kind of meadow is not uſed again and again in *one pitch*, as in the catch-meadows, that this method is only applicable to large ſtreams, or to valleys ſubject to floods; and as theſe ridges muſt be formed by manual labour, the expence of this kind of meadow muſt neceſſarily exceed the more ſimple method firſt deſcribed: and the hatches that are neceſſary to manage and temper the water, or rivers, muſt be much more expenſive than thoſe on ſmall brooks.

The expence, therefore, of the firſt making ſuch a meadow as this is, will be from twelve pounds to twenty pounds per acre, according to the difficulty of the ground, and the quantity of hatch-work required: but the improvement in the value of the land by this operation is aſtoniſhing.

The abſtract value of a good meadow of this kind may fairly be called three pounds per annum per acre; but its value, when taken as part of a farm, and particularly of a ſheep-breeding farm, is almoſt beyond computation;

 and

and when ſuch meadow is once made, it may be ſaid to be made for ever, the whole expence of keeping up the works, and watering it frequently, not exceeding five ſhillings per acre yearly; and the expence of the hatches, if well done at firſt, being a trifle for a number of years afterwards.

Suppoſed Quantity of Water-meadow in this Diſtrict.

The number of acres of land in this diſtrict, under this kind of management, has been computed, and with a tolerable degree of accuracy, to be between fifteen and twenty thouſand acres.

Indeed it has been found ſo very beneficial, that very few ſpots of land, capable of being watered, remain otherwiſe, unleſs where ſome water-mill ſtands in the way, or where ſome perſon who has the command of water above, refuſes to let it be taken out of its natural courſe to water the lands below.

Some new meadows might be made, and very great and beneficial alterations made in the

the old ones, if ſome plan could be adopted to get the command of water where neceſſary for this purpoſe; and particularly in the caſe of water-mills. A remedy for this will be hereafter propoſed.

Water-meadows do not make a Country unhealthy.

It has been alledged, by thoſe who know very little of water-meadows, that they render the country unwholeſome by making the water ſtagnant: daily obſervation proves the fact to be otherwiſe in Wiltſhire—and the reaſon is obvious. It has been already ſaid, that a water-meadow is a *hot-bed for graſs*; the action of the water on the land excites a *fermentation*; that fermentation would certainly in time end in a *putrefaction*: but the moment putrefaction begins, vegetation ends. Every farmer knows the commencement of this putrefaction, by the ſcum the water leaves on the land; and if the water is not then inſtantly taken off, the graſs will rot, and his meadow be ſpoiled for the ſeaſon.

 The

The very principle of water-meadows will not permit water to be ſtagnant in a water-mead country; it muſt be always kept in action to be of any ſervice: beſides, many of the beſt water-meadows were, in their original ſtate, a ſtagnant unwholeſome moraſs.

The draining ſuch land, and making it ſo firm, that the water may be taken off at will, muſt contribute to the healthineſs of the country, inſtead of injuring it.

Great Advantages from Water-meadows.

It is frequently aſked, how it comes to paſs that although water-meadows are ſo uſeful as to be almoſt indiſpenſible in South Wiltſhire, yet in other counties, where they are not known, the want of them is not felt; nay, that there are, even in this diſtrict, many pariſhes who have none, and even breed lambs without them?

To this it is anſwered, that the fair queſtion is not, "How do other countries do without them?" but, "How could the farmers of this diſtrict, who are happy enough to have water-meadows, purſue their preſent

present syſtem, of ſheep-breeding if thoſe meadows were taken away?" A ſyſtem which is ſaid to be more profitable to themſelves, their landlords, and the community at large, than any other that could be ſubſtituted in its room; and perhaps this queſtion cannot be anſwered better, than by exhibiting the contraſt between thoſe who have water-meadows, and thoſe who have none, in the ſame diſtrict.

Every farmer who keeps a flock of ſheep, and particularly a breeding flock, in ſo cold and late-ſpringing a diſtrict as South Wilts, knows and feels the conſequences of the month of April. "That month, between hay and graſs, in which he who has not water-meadows for his ewes and lambs, frequently has nothing!" The ewes will bring a very good lamb with hay only; perhaps a few turnips are preſerved for the lambs, which in a very favourable ſeaſon may laſt them through March; but if they are then obliged to go to hay again, the ewes ſhrink their milk, the lambs "pitch and get ſtunted," and the beſt ſummer food will not recover them. To prevent this, recourſe is had to feeding the graſs of thoſe dry meadows that are intended for hay, the young

young clover, and frequently the young wheat; in fact, every thing that is green. And who will pretend to estimate the loss that a farmer suffers by this expedient:

The ray grass on the exposed parts of this district is seldom "a bite" for the sheep till near May-day. If the season should permit any turnips to be kept till that time, which can seldom be depended on, they are not only of little nourishment to the stock, but they exhaust the land so as to prejudice the succeeding crop. And it ought to be remarked by the way, that in many parts of this district the soil is not at all favourable to the production of turnips. It therefore necessarily follows, that a farmer, under these circumstances, has no certain resource to support his stock during these months, but hay; and even in that he is sometimes disappointed, by having been obliged in the preceding spring to feed all the land which he had laid up for a hay crop: he is then obliged to buy hay, and that frequently at the distance of many miles: and, to add to his distress at this critical time, his young ewes are then brought home from wintering to be kept nearly a month on hay alone.

In

In this month, which ſo often ruins the crops, and exhauſts the pockets of thoſe ſheep-breeding farmers who have no water meadows, the water-mead farmers may be truly ſaid to be "in clover." They train up their dry meadows early, ſo as almoſt to inſure a crop of hay; they get their turnips fed off in time to ſow barley, and have the vaſt advantage of a rich fold to manure it. They ſave a month's hay, and have no occaſion to touch their field graſs till there is a good bite for their ſheep; and their lambs are as forward at May-day, as thoſe of their leſs lucky neighbours are at Midſummer: and, after all, they are almoſt certain of a crop of hay on their water meadows, let their ſeaſon be what it will.

Management of Water Meadows.

The management of water meadows is in the following way:

As ſoon as the after graſs is eaten off as bare as can be, the manager of the mead, provincially the drowner, begins cleaning out the main drain, then the main carriage, and

and then proceeds to "right up the works;" that is, to make good all the water carriages that the cattle have trodden down, and open all the drains they may have trodden in, fo as to have one tier or pitch of work ready for drowning, and which is then put under water, if water is plenty enough, during the time the drowner is righting up the next pitch. In the flowing meadows this work is, or ought to be, done early enough in the autumn, to have the whole mead ready to catch, if poffible, the firft floods after Michaelmas, the water being then "thick and good;" being the firft wafhing of the arable lands on the fides of the chalk hills, as well as of the dirt from the roads, &c. &c.

The length of this autumn watering cannot always be determined, as it depends on fituations and circumftances; but if water can be commanded in plenty, the rule is to give it a "thorough good foaking" at firft, perhaps a fortnight or three weeks, with a dry interval of a day or two; and fometimes two fortnights, with a dry interval of a week; and then the works are made as dry as poffible, to encourage the growth of the grafs. This firft foaking is to make the land fink and pitch clofe together; a circum-

ftance

ſtance of great conſequence, not only to the quantity, but to the quality, of the graſs, and particularly to encourage the ſhooting of the new roots which the graſs is continually forming, to ſupport the forced growth above.

While the graſs grows freely, a freſh watering is not wanted; but as ſoon as it flags, the watering may be repeated for a few days at a time, whenever there is an opportunity of getting water, always keeping this fundamental rule in view, to make the meadows as dry as poſſible between every watering; and to ſtop the water the moment the appearance of any ſcum on the land, ſhews that it has already had water enough.

Some meadows that will bear the water three weeks in October, November, or December, will perhaps not bear it a week in February or March; and ſometimes ſcarcely two days in April or May.

In the catch meadows watered by ſprings, the great object is to keep the works of them as dry as poſſible between the intervals of watering; and as ſuch ſituations are ſeldom affected by floods, and generally have too little water, care is neceſſary to make the moſt of the water by catching and rouſing it

as

as often as poſſible; and as the top works of every tier or pitch will be liable to get more of the water than thoſe lower down, care ſhould be taken to give the latter a longer time, ſo as to make them as equal as poſſible.

Cuſtom of feeding Meadows with Sheep.

It has already been ſaid that the great object, in this diſtrict, of an early crop of water-meadow graſs, is to enable the farmer to breed early lambs.

As ſoon as the lambs are able to travel with the ewes, perhaps about the middle of March, they begin to feed the water meadows. Care is or ought to be taken to make the meadows as dry as poſſible for ſome days before the ſheep are let in.

The graſs is hurdled out daily in portions, according to what the number of ſheep can eat in a day, to prevent their trampling the reſt; at the ſame time leaving a few open ſpaces in the hurdles for the lambs to get through, and feed forward in the freſh graſs.

One

One acre of good grafs will be fufficient for five hundred couples for a day.

On account of the quicknefs of this grafs, it is not unufual to allow the ewes and lambs to go into it with empty bellies, nor before the dew is off in a morning.

The cuftomary hours of feeding are from ten or eleven o'clock in the morning to about four or five in the evening, when the fheep are driven to fold; the fold being generally at that time of the year on the barley fallow: and the great object is to have water-mead grafs fufficient for the ewes and lambs till the barley fowing is ended.

Meadows laid up for Hay.

As foon as this firft crop of grafs is eaten off by the ewes and lambs, the water is immediately thrown over the meadows, (at this time of the year two or three days over each pitch is generally fufficient) and it is then made perfectly dry, and laid up for a hay crop. Six weeks are ufually fufficient for the growth of the crop; it feldom requires eight: and there have been inftances of great crops being produced in five.

Nature

Nature of Water-meadow Hay.

The hay of water meadows being frequently large and coarfe in its nature, it is neceffary to cut it young; and if made well, it then becomes of a peculiarly nourifhing, milky quality, either for ewes or dairy cows.

The water meadows are laid up for a fecond crop in fome inftances, but this is only ufual when hay is fcarce; not that it is fuppofed to hurt the land, but the hay is of that herbaceous, foft nature, and takes fo long time in drying, that it is feldom well made. It is ufually of much greater value to be fed with dairy cows: and for that purpofe a flafh of after grafs, fo early and fo rank, will be precifely of the fame comparative fervice to the dairy, as the fpring feed has been defcribed to be for ewes and lambs.

The cows remain in the meadows till the drowner begins to prepare for the winter watering.

Water Meadows safe for Sheep in Spring, but will rot them in Autumn.

Water meadows are reckoned to be perfectly ſafe for ſheep in the ſpring, even upon land that would rot ſheep if it was not watered; but in the autumn the beſt water meadows are ſuppoſed to be dangerous. This is at preſent an inexplicability in the operations of nature, and a diſcovery of the reaſon might lead perhaps, in ſome meaſure, to a diſcovery of the cauſes of the rot in ſheep *. But the circumſtance itſelf is rather an advantage than a diſadvantage to this diſtrict, as it obliges the farmers to keep a few dairy cows to feed the water meadows in autumn, and to provide artificial graſſes, or other green crops for their ſheep, during that period.

* See Paper, by the author of this book, on the diſorder in animals, termed Staggers, publiſhed in Dr. Anderſon's Agricultural Recreations, about June or July, 1799.

Proper Soil for Water Meadows.

From what has been ſo repeatedly urged on the neceſſity of making water meadows dry, as well as wet, every reader muſt have inferred the advantage of having them, if poſſible, on a warm abſorbent bottom *.

The bottom or ſub-ſoil of a water mead is of much more conſequence than the quality or the depth of the top ſoil. Not but that the land on peaty or clay bottoms may be conſiderably improved by watering; and there are many good water meadows on ſuch ſoils, but they are not ſo deſirable, on account of the difficulty of draining the water

* There is a ſtriking proof of the truth of this remark in the water meadows near Hungerford, and particularly at Standen. Although they are laid out in no regular plan, and in many inſtances there are no drains to empty the water carriages, yet the gravel bottom is ſo very abſorbent, that the water will ſoak out in a few hours, and the meadows be left as dry as if they were watered on the moſt ſyſtematic plan: few meadows in the country produce better crops, either of ſpring feed or of hay.

out

out of them, and making them firm enough to bear treading.

A loofe gravel, or what perhaps is ftill better, a bed of broken flints, with little or no intermixture of earth, whenever it can be obtained, is the moft defirable bottom.

On many of the beft water meadows in this diftrict, where the bottom is a warm, abforbent gravel, or rather a bed of broken flints, the foil is not quite fix inches deep; and that depth is quite fufficient, in thofe feafons when water is plenty, as the grafs will root in the warm gravel in preference to the beft top foil whatever; and fuch meadows always produce the earlieft grafs in the fpring. Nor is it fo very material of what kind of graffes the herbage is compofed when the meadow is made: that kind will always predominate which agrees beft with the foil and the water, provided the fupply of water is regular and conftant every winter; in other words, that kind will predominate which will bear wet and dry, and fome of the worft graffes, in their native ftate, will become the beft when made fucculent by plenty of water.

Use of Water Meadows.

The water meadows of Wiltſhire and the neighbouring counties are a branch of huſbandry that can never be too much recommended.

In ſpeaking of water meadows, it has been objected that they are local; and that there are many parts of the kingdom in which they neither can be made, nor are they neceſſary if they could be made.

There are undoubtedly, ſays the Communication to the Board, many parts of the kingdom in which water meadows cannot be made*; but nobody will deny but that there are thouſands of ſituations where they could be made, in which they have never been tried. And as for their uſe, it may be ſtrongly ſuſpected, that thoſe who deny it have never been in Wiltſhire in the month of April. Let thoſe who call it in queſtion point out a

* This book, however, goes to prove, that by means of art and machinery water meadows can be made any where! W. T.

ſubſtitute

fubftitute on which the farmer can, with equal certainty, depend for the fuftenance of his flock in that trying month.

Whatever may be the earlinefs of the feafon, with refpect to the fpringing of either ray grafs or meadow grafs, water meadows will be a month before either.

And notwithftanding the great advantages that have been derived from the introduction of green winter crops, fuch as turnips, rape, cabbages, &c. (advantages to this kingdom almoft beyond eftimate) yet this may be laid down as a certain maxim, that whether the winter be hard or mild—whether the fpring be late or early, nature will always have, in this climate, an "*interregnum*" between the end of one year's food and the beginning of another. The fame temperature of the air in the fpring, which brings on the grafs, will occafion all green winter crops to run to feed, and not only to loofe their own nourifhing quality, but to exhauft the land on which they grow.

A moment's reflection will convince every man, that nature muft unavoidably and conftantly leave this chafm in the year's food. Winter, though driven into a fmall com-

paſs, is ſtill winter, and art alone can expunge it from the Kalendar.

Hot-houſes and hot-beds have, in a great meaſure, done this for the gardener. Water meadows, which are hot-beds for graſs, will as effectually do it for the farmer. How neceſſary is it, therefore, to impreſs the value of this branch of huſbandry on the minds of all the land-owners in the kingdom.

It is not only the moſt valuable, but the moſt permanent, of all improvements in huſbandry. It not only improves the land on which it is made, but makes all the adjoining land better by its produce; and it differs in one very material reſpect from all other improvements that a landlord can make for a tenant; that is to ſay, that time will even make it better, and that the careleſſneſs of a tenant cannot make it much worſe.

Before I take leave of the very intereſting examples of irrigation which this county affords, I think it proper to notice a very particular objection to the extenſion of ſuch canals as may be neceſſary to a complete watering; which, while it ariſes from the fear of deſtroying the ſources of agricultural irrigation on the one hand, ſhould operate with

with double force on the other, in favour of that combination of interefts, which nothing lefs than a fyftem of national irrigation can give.

In page 156 of the Wiltfhire Report, it is ftated that only one canal, viz. the Thames and Severn navigation, paffes through that county. That feveral others have been propofed, and that fome are yet contemplated; " but the fear that canals will deprive the water meadows of water, makes many of the landholders averfe to them." If Government would ftep forward with the primary means of general fupply which is contemplated in my defign, this, with a thoufand other objections which create an endlefs expence, and wafte much of the national time in Parliament, would for ever after vanifh; and plenty and conveniency would be everywhere fo prevalent, that the affections of the community might harmonize in fuperabundance; and the difquiet of party contefts become loft in the midft of profufion.

IRRIGATION OF THE COUNTY OF WORCESTER.

The great example of irrigation which comprifes the whole fyftem of this county, is faid to exift in the hands of one fingle family. I fhall therefore content myfelf with the account of it which has been tranfmitted to the Surveyor of that county, and by him to the Board of Agriculture.

The plan of watering the lands in this neighbourhood, belonging to the Foley family, is fhortly as follows:

It is, in the firft place, neceffary to obferve, that all the mills on the brook, or ftream of water, as foon as it enters on their property, until it unites with the river Stour, for near three miles, belong to them; of courfe they have the control of the water. At the upper end of the ftream are three or four water courfes, made for feveral miles upon a level to the different farms that are watered; and the whole ftream is divided in a manner proportioned to the quantity of land each

each courſe is intended to water. The farms that receive this valuable acquiſition are eight or nine, and the quantity of land watered upon the whole of them is between three and four hundred acres. The quality of the ſoil, in general, is a very light ſand, and many parts of it mixed with gravel: by the diviſion of the ſtream as above, each farm has its portion of water repeated from two days to a week, every three weeks throughout the year; and in order to prevent the leaſt diſpute between the tenants, reſpecting the diſtribution of the water, a perſon is appointed to turn it from one perſon's land to the next in turn, at certain ſtated times fixed for this purpoſe.

The farmer then takes to the management of it, and floods ſuch parts of his lands as are generally prepared to receive it. There are very few of them that mow the whole of the land they water, but mow and graze it alternately, in ſuch a manner that they uſe the water at all ſeaſons of the year in their turn. A very conſiderable quantity of land in this neighbourhood is well ſituated to receive this improvement, if the ſtream was ſufficient for the purpoſe, beſides the number of acres already mentioned, the greater part

of

of which was formerly a very poor arable land, and not worth more than five ſhillings an acre. The induſtrious farmers are very attentive to the uſe of water; all the gutters are cut for floating, with the uſe of a water level; and the more numerous the gutters are, the greater quantity of graſs the land produces.

In ſome ſituations, with the uſe of little ſtop gates, the gutters are cut deep enough to drain the land they are made to float: this circumſtance, where the land requires it, is worthy of great attention. The whole plan of irrigation, where practiſed (and very few farms indeed but what will admit of it in ſome degree), is, beyond a doubt the firſt and greateſt improvement, at the leaſt expence, ever diſcovered.

IRRIGATION IN DEVONSHIRE.

There are many inventions for irrigation in the county of Devon, and ſome of them (to the great honor and profit of proprietors) are carried into actual execution, on the encouragement of their own ſole reaſon, without example to guide their judgment; and on a ſcale which exhibits a ſpecimen to other countries, for the combination of commercial and agricultural advantages, in the items of agricultural irrigation, mill works, and canals.

Mr. Leach, a plain man, and ſurveyor by profeſſion, who ſtepped into the then little trodden path of a Treatiſe upon the Science of Inland Navigation, with ideas which would have done honor to an abler pen, ſo early as the year 1791, reduces his obſervation to nearly this ſummary maxim, that *where water is, there may navigation be alſo*. I ſhall be bold enough, before I have done with the ſubject, to ſtep one grade farther; for I dare pledge myſelf to ſhew, that there

there is not a tract of one mile square in England into which canals may not be carried advantageously, if a proper national system is adopted under a rule similar to the Chinese maxim, which is said to compel the emperor himself to dig the first spade of earth out of his most favourite grounds, and to assure his people with an audible voice, that *no private pleasure shall obstruct the public good.*

But to return to Mr. Leach, he recommends an attention to combination in the following nervous and farmer-like language:

Agriculture, says he, is the most useful and ancient art of any whatsoever; and which most noble art, together with commerce, are the chief pillars and support of these kingdoms. It is the duty of every one, who has any regard to his duty, to promote and encourage these useful arts; and there is no contrivance whatsoever that will go so far to this end as the construction of inland navigation, and extending them into the interior of every part of the kingdom: a thing very possible to be done (says he) at any place where there is a river or stream of running water. For it may be affirmed as a fact, as it is confirmed to me by the clear-

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eſt demonſtration, that there is hardly one ſtream or river of running water in the univerſe, where there is ſufficient water to work a common flour-mill, but it is capable of being made navigable.

In various parts of his work he dwells particularly on the agricultural advantages which are to be expected from the conveyance of manure, ſea-ſand, and other materials in huſbandry; but though it is probable that the ſurveys he was engaged on in Cornwall and Devon, may have contributed to ſtimulate enterpriſe, and expedite execution: one of the moſt intereſting inſtances of combined powers, in this way, ſeems to have reſulted from caſualty in the operations of James Templer, Eſq.; to whom we are indebted for new and valuable lights in the ſcience of *irrigation, by means of inland navigation.*

In the agricultural ſurvey of the County of Devon, which was made in the year 1794, by Mr. Fraſer, under directions from the Board of Agriculture, we are told that James Templer, Eſq. of Stover, in the County of Devon, has, in the way of communication by canals, and in turning them to advantage by watering the land adjacent, introduced

introduced a *principle* which is capable of wonderful extenſion.

This gentleman has by management in the diſtribution of water, from a canal communicating with the ſea at Teignmouth, united the *utile* and *dulce* with much propriety and effect; and which, at the ſame time that it reflects great honour on his genius, and muſt be productive of great perſonal emolument, has brought into light a principle of improvement not hitherto at all attended to; but properly conſidered, will ſhew that navigable canals may be rendered of advantage to agriculture, in a degree which is not thought of where they are confined merely to the purpoſes of conveying articles of commerce.

The water meadows belonging to James Templer, Eſq. above mentioned, are ſituated in the pariſh of Teigngrace; and are under management which is perhaps no where excelled.

The ſoil in moſt parts of this pariſh is a very poor thin black mould, on a ſtratum of cold clay, which is exported in great quantities for the uſe of the potteries in the neighbourhood of Liverpool, and other parts of the kingdom, forming a very conſiderable branch of

of traffic. This circumſtance induced Mr. Templer to form a navigable canal for the conveyance of this clay to Teignmouth, the port of ſhipping, without at firſt adverting to the uſe of ſuch a canal for the purpoſe of watering the land. His taſte for rural improvement ſoon made him perceive the advantages ariſing from this circumſtance.

A very conſiderable tract of marſhy land adjoining to the lower part of his canal, which did not produce above eight or ten ſhillings per acre, ſome not five, he drained and levelled. After which, by forming ſurface-conductors for the overplus water of the canal, and well-contrived ſluices, he diſtributed the water of the winter floods, enriched with the ſlime from the higher grounds, over theſe marſhes, now converted into verdant meadows. Theſe diſtributary ſluices are extremely ſimple and judicious in their conſtruction. They conſiſt of a number of trunks, placed at various diſtances, to each of which a plug is fitted. The trunks are placed above the level of the water neceſſary for navigating the canal; and when the floods fill the canal, theſe plugs are taken out, and the water is inſtantly diſtributed in a very beautiful man-

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ner over the ſurface of the meadows; and is eaſily and ſpeedily ſtopped when it is conceived they have run long enough.

Mr. Templer has followed the ſame ſyſtem in the upper line of his canal, and with ſimilar ſucceſs. Theſe meadows he lets out for paſture grounds to his tenants; and it is curious to remark the great difficulty he had to perſuade them of the utility of this ſort of management. He was even obliged to bribe them to purſue their own advantage, by giving a remittance of part of their rent to thoſe who were moſt induſtrious in draining, and watching the opportunity of diſtributing the water in the floods: ſo very difficult is it to excite the generality of people to try new improvements! They are now, however, very ſenſible of the advantages ariſing from this ſyſtem, and are very glad to get an acre of meadow for 40s. and 3l. for which before they unwillingly paid 10s.

Another eſſential advantage produced by this canal, is the fine rich mud, mixed with rotten leaves of trees, &c. which is waſhed down by the rain, and depoſited in the canal, This, in ſummer time, is dragged out with long-tined harrows, by the aid of a couple of horſes or bullocks, and afterwards mixed

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with lime for the upper lands. This rich mud is a manure of itſelf, and he allows his tenants to take it freely for their own uſe.

In this manner he is accuſtoming his tenants to an induſtry which betters their own circumſtances, while, without laying out any conſiderable expence himſelf, his land is ſo rapidly increaſing in value, it is ſuppoſed it will in a few years equal the intereſt of the money laid out upon the canal, independent of the trade which is daily increaſing. A moſt wonderful effect is ſaid to be produced by laying ſea ſand on the meadows, which ſand forms a back carriage for the bargemen who carry the clay to Teignmouth. What renders theſe operations more intereſting, is, that theſe lands are in themſelves naturally ſo barren, that it was thought impoſſible to improve them; and Mr. Templer was the object almoſt of ridicule to his neighbours.

The advantages ariſing from the canal, and from his experiments, not only to him but to the neighbouring country, which will be more and more benefited, are now generally confeſſed; and if it ſhould be hereafter connected with any canals on the higher grounds of Dartmoor, the benefits ariſing

from it will be ſo widely extended, as to render it a vaſt advantage to the public.

In the further accounts of this agricultural ſurvey of the County of Devon, we find that the farmers ſouthwardly from Stover, appear to be every where ſenſible of the advantages of Mr. Templer's improvements, and every little ſtream is applied more or leſs to the watering of their grounds. They alſo catch the floods on the roads from the declivity of the hills, and convert them to this purpoſe.

So far the account of Mr. Templer's improvements which I have collected from the ſurvey above recited, as a ſtriking inſtance of *what* may be done!—But, as I purpoſe to go farther, with a view of certain places where *much* may be done, I beg leave to notice a few particulars touching the Foreſt of Dartmoor as an example, which being chiefly the property of his Royal Highneſs the Prince of Wales, is in hands competent to great undertakings, where he may deem them to be deſigns which may benefit his country.

Mr. Fraſer deſcribes the weſtern diſtrict of the County of Devon to be only patches in cultivation. By far the greateſt part, ſays he, conſiſts of undivided waſtes and commons,

mons, amounting to between 2 and 300,000 acres of land, if not more than that quantity.

In the center of theſe waſtes is ſituated the Foreſt of Dartmoor, the property of his Royal Highneſs the Prince of Wales.

This foreſt is the higheſt part of the diſtrict. In the north part of this foreſt, and the higheſt grounds, the ſoil conſiſts of extenſive tracts of a wet turf or peat of a great depth; in other parts of a light black ſoil or gravelly, intermixed with a yellowiſh or whitiſh clay. Declining from the foreſt in other parts of the diſtrict, it partakes more or leſs of ſimilar qualities; chiefly light black peaty earth or gravelly. Many of the vales both on the foreſt, and in other parts of the diſtrict, appear very capable of improvement; and the whole, if ſtocked by cattle and ſheep, capable of being made the ſource of additional wealth to the kingdom.

The mountains of Dartmoor form the grand reſervoir, from whence water is plentifully diſtributed to all parts of the county.

The waters, which empty into St. George's Channel on the one hand, and Briſtol Channel on the other, are ſaid to riſe within three quarters of a mile of each other; and their

ſources are computed to be not more than between eight and nine hundred feet above the level of the ſea; and yet except ſome of the *tors*, this ſummit is higher than any other part of Dartmoor; ſo that the height of this country is by no means ſo formidable as it appears to the eye of common obſervation.

Deſcending from this ſummit there is an immenſe extent of mountainous land, thro' which there are vallies and levels to be found, by which canals might be extended on a level for miles together.

The concluſion to be inferred from theſe premiſes is certainly founded in truth, when it is ſuppoſed that water cannot be more economically uſed, or to greater advantage, than in improving ſuch tracts of waſte lands as thoſe about Dartmoor, by means of canals and ducts for the purpoſe of manuring and irrigating them; and that this is practicable in various productive ways, adjuſted to the circumſtances of theſe or other particular premiſes, upon general principles which will apply every where, I flatter myſelf I ſhall be able to demonſtrate in the ulterior relations of this book. By the means I ſhall propoſe, canals may be eaſily extended into all parts

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of this waſte, and communicated thence to the ſea by Mr. Templer's canal and other routes, by which lime, coals, ſea ſand, with other manures, &c. could be conveyed to this waſte, and the granite, tin, copper, &c. with which it abounds, would form a trade in return. The reſult of theſe operations would be, that agriculture which, to the ſurpriſe of ſtrangers, has proceeded ſo ſhort a way from the ſea coaſts, would penetrate to the centre of Dartmoor, and the brown heath would ſoon become changed to a verdant green. Inſtead of miſerable half-ſtarved ſheep, which are permitted to wander over theſe wilds without the foſtering hand of a ſhepherd, regular flocks would be conducted with ſkill and care, and give an additional ſource of wealth to the community. By facilitating the carriage, even by ſmall canals, the expence of manure would be reduced; whereby the farmer might improve more land than he could manage otherwiſe, add beauty to his tenement, and value to the eſtate of his landlord.

In proportion to the extenſion of canals, the number of horſes and mules employed as carriers will always be reduced; and as provender is thereby ſaved in this item, pro-

visions will become more abundant in another, by the increase of oxen and sheep.

To use the words of my friend Mr. Fulton, (which it is difficult to avoid, seeing we have for several years thought and written with little variation from the same expressions, while at the distance of three thousand miles apart, and then without knowledge of each other)—Is it not interesting on this point to see the disparity between land and water carriage: in Cornwall a mule usually carries three hundred pounds weight, (and even in this way is Dartmoor said to be manured,) while upon a small canal, the construction whereof I apprehend would not exceed three hundred pounds per mile, throughout the kingdom in nett expence, one mule will convey twenty tons with ease: hence one mule performs the ordinary work of one hundred and thirty, and the greater part of mules and horses might thus go to cheapen the impetus of neck-breaking pleasures, to lighten the burthens of manual labour, or the better purposes of that rustic implement the plough, which gives such wonderful effect towards the multiplication of our species, and the production of domestic plenty.

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The invention of the ſteam-engine has been conſidered as a contrivance of the firſt importance to mankind; becauſe of its immenſely increaſed capacity in ſaving animal labour, and reducing the burthenſome expence of employing and feeding, as formerly, ſuch numbers as were then neceſſary to give rotary motion to an infinity of machinery.

Thoſe improvements of this engine which contribute to ſave coal, have been viewed as a material conſideration in the mining intereſt; and canals, which have reduced the expence of carriage in much greater ratio than the grades of power between man and horſe, or between horſe and waggon, muſt, with their powerful influence in irrigation, neceſſarily militate to cheapen the price, and multiply the ſupply of human comforts.

If the tradeſmen of the ſeveral towns are enabled to procure heavy articles at a reduced carriage, their cuſtomers all feel the benefit of a proportionate price, which nevertheleſs ſecures equally a fair profit to the vendor. If coals are thus reduced in their carriage, or new mines become thus opened to market, the cottager is enabled to burn more of them; and numerous bleſſings are the offſpring of a comfortable hearth.

The ſame mode of reaſoning applies to every ſpecies of purſuit which requires the transfer of heavy articles; and regardleſs of the ſcience of irrigation, to the aid whereof canals may be ſo conſtructed as to afford inexhauſtible reſources, there is no point in which they can be viewed but they exhibit ineſtimable advantages to the bulk of ſociety; becauſe every amendment which reduces the quantity of animal labour, or which yields a greater abundance with the ſame manual applications, muſt render the accommodations of life more plentiful, cheap, and diſtributive.

When two perſons, for example, are preſent at the common mart of traffic, with any quid pro quo of commerce which they incline to exchange, the barter will meet upon equal terms, and each will obtain a reaſonable proportion of the ſurplus commodity of the other; but, if one perſon has his produce upon the ſpot, and the other brings the article wanted a mile, the expence of that mile's carriage will neceſſarily reduce the quantity thereof to be given, upon the ſame principles of fair trading, in proportion to the coſt of one mile's conveyance.

In the ſame way every additional mile's carriage

carriage muſt make a proportionate reduction of the quantity of the transferred articles to be delivered; even to the prohibition of intercourſe, unleſs the inland party ſubmits to the impoſitions of neceſſity. Now at the ſame rates for animal conveyance, apart from attendance, there can be no material difference whether one hundred and thirty mules go one mile to bring each a ſack of corn, or whether one mule goes one mile one hundred and thirty times over, to perform the ſame quantity of carriage. But if, by the conſtruction of a canal of one mile in length, with the price of one hundred and twenty-nine mules, the remaining one is enabled to perform the ſame transfer, he thereby ſaves to the community the feeding, attendance, and equipments of one hundred and twenty-nine mules per day, and the charge for conveyance of merchandize will be proportionably leſſened; although thoſe perſons who are employed as carriers will receive the ſame degree of fair profit, as if no canal had been conſtructed, and yield to the community a multiplied reſult.

If we farther view the extenſion of inland canals, in reſpect to the various purpoſes of agricultural improvement for which they are capacitated,

capacitated, the mind muſt contemplate with ſurpriſe the wonderful proſpect of multiplied reſources which will proceed from the moſt ſteril and mooriſh parts of the kingdom; and which Mr. Templer's actual improvements have demonſtrated ſound data, to expect. The mining countries perhaps might produce corn and fleſh in ſufficient quantities for their home conſumption; and the balance of traffic would remain as an annual accumulation to penetrate farther into the earth, or to enrich and beautify its ſurface.

If the extenſion of canals can facilitate and cheapen the expence of manure, we may behold every little farmer in a condition to improve a greater quantity of ſoil; to poliſh the eſtate he poſſeſſes to the enrichment of his landlord; and to contribute additional benefits to the weal of ſociety. The features of content would thus diſpel the gloom of abject wretchedneſs from his brow; and he would behold that manlineſs of antient days in his growing offſpring, which can alone contribute permanent ſafety and proſperity to his country.

In viewing canals as agents to agriculture, we ſhould not forget the innumerable advantages which have reſulted from the uſe of

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ſea-land, when it admits of carriage to the interior parts of the kingdom; and if the lands are ſuppoſed to receive melioration from the carbonic acid, or from any particular ſolid quality contained in that or the ſhells it is mixed with, it may merit conſideration whether croſs cuts are not practicable in moſt parts of the kingdom, which would juſtify an actual extenſion upon the ſole principle of this ſpecies of huſbandry, independent of other purpoſes. But if it is ſimply the ſaline that is required, it may prove no difficult matter to form reſervoirs upon the ſeveral eminences which overtop the reſpective neighbourhoods, by extending pipes in the nature of water-works, as an undertaking of Government, which being properly ſyſtemized, may accommodate agriculture in the remoteſt parts, and form ſalt-water baths in the city of London, or extend them into every pariſh in the kingdom, and ornament the pleaſure grounds of thoſe who may prefer ſuch, with caſcades and fountains of a ſpecies which no other country exhibits.

There are ſome other conſiderations in favour of agricultural canals, which ſhould not be omitted.

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By land carriage it is abſolutely impoſſible to perform a ſufficient transfer of manure, to gain any conſiderable advantage of time and quantity during the continuance of a ſeaſon; but by agricultural canals the quantity may be multiplied, the price reduced, and the ſeaſon extended to a ſpacious tract of farm.

This increaſe of improvement will remunerate its accumulation with manifold force. The quantity of articles carried upon a canal will enable conveyance at leſs expence; or the ſurplus monies may be applied to the diſtribution of more minute bleſſings, into the ſmaller arteries of irrigation.

To facilitate and expedite theſe great ends, it would be a deſirable attainment to effect ſome more cheap and ſimple method of raiſing a ſupply of water equal to the undertaking, from the lower reſources of lakes, rivers, and the tides; for the conſtruction, wear, and tear of the ſteam engine, and other expenſive machinery, together with their contingent charges, are a conſiderable drawback on the advantages of an agricultural uſe of water. I have endeavoured to contribute my mite to this kind of improvement in the following pages: I ſubmit them

to the public, in hopes that they may ſtimulate ſome more able genius to add his thoughts on this intereſting particular.

A Deſign for obtaining a Mechanical Power from the mere Motion of the Waters; and for diſtributing that Power into every Part of Great Britain, ſo that the Supply may be rendered equal to any given Demand which may be required.

Mr. Ferguſon defines a fluid to be "a body that yields to the leaſt preſſure, or difference of preſſures."—"Its particles," he ſays, "are hard, ſince no fluid, except air or ſteam, can be preſſed into a leſs ſpace than it naturally poſſeſſes."

It appears to me, that from theſe properties we may deduce ſufficient principles to juſtify an experiment upon the mere motion of the ſea; for there ſeems to be no doubt that the force by which the flowing tide is impelled, does at all times yield a difference of preſſure, of ſufficient importance to overcome the reſiſtance which may be impeded by an equal fluid in a ſtate of reſt: for as each

each particle is equally free to move, it will always move towards that point where there is the leaſt preſſure, and recede from that where there is the moſt.

Let an air veſſel, for example, be conſtructed with a valve near its bottom, and a main pipe aſcending from its ſide: let it then be filled up with water; then fill a common ſyringe with water, and inject it through the tube which contains the valve: I apprehend there can be little doubt that the water contained in the veſſel will riſe in the main pipe in proportion to the quantity injected; becauſe of the force applied to the ſyringe, which affords a difference of preſſure upon particles otherwiſe equal. Upon a ſimilar principle a wedge is made to cleave the ſame tree, or enter the ſame timber of which it is formed, by means of the ſtroke or preſſure applied.

There is a copying machine invented, by Mr. Bramah, which acts by means of a very ſmall forcing pump. This injects water into a cylinder, ſo as to move a piſton and table upwards. I am told that the power of this little contrivance is ſo great, as to preſs a block of wood to pieces which is ſix inches

inches ſquare: I have not ſeen this experiment.

Mr. Foulds, at the London-bridge water-works, has approached ſtill nearer to my idea, by combining the properties of fluid matter through the help of an air veſſel; thus availing himſelf of elaſticity, for the purpoſe of filling the mains of the London-bridge water-works, which were formerly ſupplied by means of an elevated tower, conſtructed on the ſimple fountain principle; into this the water was raiſed by the ſame forcing pumps which are now applied to the air veſſel; and was from thence diſtributed from the tower into the mains of the water-works.

The chief difference between Mr. Foulds's method and my conjecture is, that I ſuppoſe the motion of the tide, when governed by a proper direction, will be fully competent to open the valves of an air veſſel; by which means the water will be injected and raiſed into the mains by the elaſtic action of the compreſſed air upon its ſurface, as in the caſe of the London water-works, without the force of any additional power.

I do not pretend to form an obſtinate concluſion, that this is the only method that will

will anſwer; that this is complete in itſelf without amendment or aid; that this is either without objections to it, or am I certain that it will anſwer at all. It ſtrikes me as a deſign worthy of experiment, although I perceive ſome difficulties to be overcome; ſuch as the ſiltage of the ſand which the ſea brings with it: this may happen to choke the valves, or fill up the air veſſel and ducts: it may be requiſite to contrive ſucceſſive valves to meet the riſe of the tide, and to ſhut each other by means of a click or ſpring: there is alſo a neceſſity to bring the fluid into a ſtate of equilibrium within and without the air veſſel, before the valve will open at all; and to this muſt be added the motion of the ſea, from whence the difference of preſſure or preponderance is to be expected. Succeſſive lights, however, will ariſe from an inveſtigation of the ſubject; and I am induced to hope that theſe would amply reward the inquiry.

It may perhaps be ſtill farther neceſſary to add ſome ſmall power by means of machinery, to help the action of the air veſſel; but if even this ſucceeds, it will be an ineſtimable acquiſition to agriculture, manufactures, and commerce: for I have no heſita-

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tion in saying, that the present system of practical hydraulics is, in many things, imperfect, partial, and puerile; and that it may be amended in the items of inland navigation, irrigation, and drainage, as well as in respect to mechanical application, and the watering of towns and cities. I will even add, that if the whole of the demand for irrigating the kingdom entirely through every part of it is to be supplied, by machinery, from the lakes of Cumberland, &c. or from the flow of the tide, and by the total application of machinery, that the Government may draw a powerful revenue from such a national operation; and the country would be enriched by it, to the advantage of all its inhabitants.

This position applies equally to Scotland and to Ireland; and, indeed, to every other country; for all countries have what is termed a back bone, land's height, or highest point or ridge of elevation between the waters which discharge themselves one way, and those which run in another direction: yet so attentive are mankind to individual interests, and so limited have been the mere local operation of civil engineers, that the savings of wealth which a combination of

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he very powers that have been ſeparately applied would have produced, ſeems to be a ſubject which has not occurred to them. But it is nevertheleſs a topic which admits of ample demonſtration; and of eſtimates, founded on experience, which may be made to approximate nearly to a practical reſult.

Suppoſe, for example, that Government were to take into their own hands the conſtruction of *one grand national water-work*, for the purpoſe of elevating a ſufficient ſupply of freſh and ſalt water from the moſt convenient waters below, to the moſt elevated hills, mountains, and peaks; forming ſpacious reſervoirs in the coves of theſe ſteril regions; and that a grand communication, by mains, pipes, and canals, was formed from one hill or eminence to another throughout all the dividing ridges which ſeparate the principal waters and rivers of the kingdom. There could, in this caſe, be no doubt remaining, upon principles long proved by practice, that from baſins or reſervoirs erected near theſe ſummits, water would diſtribute itſelf afterwards by the mere act of its own gravity, duly regiſtered or governed by air tubes, into every acre in the iſland; and from thence diſcharge its ſurplus

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to the sea, through the ordinary sewers which nature has designed.

This capacity being thus once obtained, the supply would be always regulated and justified by the extent of the demand; and, from hence, all the smaller drains of private navigation, culinary purposes, irrigation, and manufactures, might be furnished at a moderate rent. This would complete an inestimable system of public economy, mutually redounding to the benefit of the crown and the subject, and highly honorable to British science, and to this age of superior improvement.

If we wish, however, to be moreover satisfied in regard to the pecuniary advantages which may be made to flow from this medium of public economy, we arc furnished with accurate data for an estimate which may approach near enough to our purpose to form a satisfactory fiscal calculation. The heights of the principal hills and mountains in England are as follow:

	Feet.
Skiddaw, in Cumberland, is above Broad Water — - —	3300
Axe-Edge Peak, in Derbyſhire, is above Derby — —	2100
Bunſter Hill, in Staffordſhire, is above Trent — — —	1200
Exton Hill, above the level of the Dove — — —	700
And Dartmoor, above the ſea, about	1000
Making in all theſe ſummits -	8300
The mean elevation being - -	1650

The point of partage of the Grand Trunk Canal, which traverſes the heart of the kingdom, through the county of Stafford, in its way from Liverpool to Hull, has a riſe of 316 feet, and a fall of 326 feet, yielding a mean elevation of 321 feet, which may, I think, be fairly taken as the medium partage between the rivers of England that empty into the Britiſh ocean, and thoſe which diſembogue themſelves into the Iriſh ſea.

By

By an admeaſurement upon Mr. Cary's large map, I find that a main trunk or canal, of ſix hundred miles in length, would be ſufficient to extend a ſupply of water throughout the kingdom, from the boundary of Scotland to the Land's end, along the dividing ridge, or moſt elevated land in the country; from whence its own gravitation would convey it everywhere elſe, through the pipes and canals of individuals, or of aſſociated companies: but, to render the diſtribution more complete through every part of the kingdom, I will add nine hundred miles more as an allowance for public branches along the principal dividing heights, and take a greater number of elevations into the account, ſo as to eſtimate the national diſtribution of water to be a main of fifteen hundred miles extent, having its reſervoirs elevated at the average riſe of 900 feet; which is nearly a mean between the mountain ſummits, and the partage of the Grand Trunk Canal.

Thus, I preſume, every objection will be removed in reſpect to the principle; which, like that whereby the human body is ſupplied from the grand reſervoir of the heart into the ſmalleſt arteries of the head, the

fingers, and the toes, would diſtribute its bounteous influence into the moſt diſtant canal, into every mill-pond which ſhould be deſired, into every farm and garden which ſhould be cultivated, into every tan yard which requires it, into every bath, caſcade, and fiſhpond of luxury; into every fountain of ornament or uſe which might be deſirable; into every houſe which ſhould be inhabited; into every kitchen which ſhould cook a dinner; and into every water cloſet which ſhould accommodate the remaining occaſions of the family.

But it is a misfortune which I have often obſerved, that men are prone to confound a principle, from which you calculate with a deſign to incur the whole expence. Now, as I admit a very material diſtinction between what is theoretically poſſible, and that which is practically expedient, I think it proper to premiſe an explanation before I attempt an eſtimate. I would have it underſtood, that it is my opinion that all elevated countries, which neglect to conſtruct an elevated navigation, are purſuing a defective ſyſtem of canal conveyance: a ſyſtem which bids fairly to exhauſt the natural ſupply of water, to

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ſilt up the natural ſewers of the country, to injure the depths of river navigation, to create ill blood and ſtrife between party and party, and to terminate in a thouſand diſappointments, becauſe there are not ſprings enough for every man.

Hence it is that I would have the *nation* to begin at the right end of the buſineſs, by obtaining a command of water which ſhould be competent to all its occaſions; and I will endeavour to make a ſufficient eſtimate, to ſhew the nature of the expence and profit which I contemplate; but I would not have it from thence inferred that I would expect a prompt execution of the deſign: it is ſufficient to lay out the plan, and carry into effect ſuch parts of it as may be found progreſſively convenient; for whether ſuch a deſign has a capacity for completion in five years, or five hundred years, is a matter reſting wholly upon contingencies, and muſt greatly depend on its points of remuneration. It ſhould be nevertheleſs remembered, that every great national undertaking has its beginning; and it is certainly highly honorable to the reign which commences ſuch works of bounty and munificence.

It would be adviſable in an undertaking of this nature, that if the coſt of machinery cannot be done away by the ſubſtitution of ſome ſuch invention as I have endeavoured to contrive an application of to the mere motion of the ſea, that the expence ſhould be reduced ſo far as it may be found practicable, by the adoption of co-operative powers. The horizontal wind-mill is one which may be applied to great advantage in all windy ſituations; for it matters not in what direction the wind comes, or that it is attended; yet it will always be found a ſelf-acting machine, whenſoever the wind blows at any point: and by this means a conſiderable quantity of water may be alſo forced into the air-veſſel, independent of the action of the tide.

Indeed I think it will not be very difficult to contrive a helping machine to the motion of the valves, which it is neceſſary to govern with mathematical nicety.

By the help of ſurface-conductors the rain may be collected from the mountain tops into the various reſervoirs which hilly countries generally admit of in cheap and ſterile ſituations, to a very conſiderable extent; into theſe, according to their various levels,

levels, many little ſtreams of water may be directed; and numerous inſtances will occur, where the aſſiſtance of the cheap lifting-wheel, which I have herein before deſcribed, will re-elevate the overflow to baſins on a higher eminence; from whence it may be again diſtributed in droughthy ſeaſons. There is, under contemplation of this little branch of economy, one circumſtance to which I beg leave to call the attention of every man who manages a farm. The cheapneſs of this laſt machine brings it within every farmer's reach; and if he will only be at the pains to uſe it, during the time for manuring his graſs lands, for the purpoſe of mixing liquid manure in a pit properly ſituated for diſtributing ſuch into ſurface-drains through his grounds, he will find himſelf wonderfully rewarded by an abundant crop of graſs, of the richeſt quality, even progreſſively from the barren heath.

But when we are eſtimating a deſign in order to determine its expediency, it will always be found ſafeſt to allow the moſt expenſive methods; which will not only enſure leſs diſappointment in any caſe, but will alſo leave more room to ſpirit up the execu-

tion

tion by the ſucceſſive amendments which may occur.

I ſhall therefore make the actual practice, in water-works moved by the power of ſteam, the baſis of my calculations; and if I ſhould fortunately ſucceed in any new method or improvement, by which a national ſaving ſhall be attained, I truſt I ſhall at leaſt reap the credit of it, although thoſe who have the benefit of a more fortunate patronage may be more likely to enjoy its pecuniary advantages.

Of the Power and Expence of conſtructing a National Irrigation; and of communicating a Regulating Main throughout the Kingdom of England, to be fed wholly from the lower Level of the Tide, Lakes, and Rivers, by Means of Machinery.

In purſuing this inquiry I ſhall adopt the principle of ſafety which I have juſt laid down, and ſhall found my calculations on the moſt expenſive machinery.

In my Political Economy of Inland Navigation, Irrigation, and Drainage, publiſhed laſt

laſt year by Mr. Faulder, in Bond-ſtreet, in calculating the power and expence demanded in my plan for inſulating the city of London by means of a navigable canal, I have taken the actual practice of the ſteam engine which is employed daily in the Shadwell water works as my datum; and I have, in that work, gone into many detail conſiderations and eſtimates which may be eaſily referred to, and which it would be, therefore, ſuperfluous to repeat.

By this engine the water is raiſed ninety feet; its pump-barrel is twelve inches; and twenty-two ſtrokes, of ſix feet each, are performed in one minute.

The coſt of this engine is eſtimated at two thouſand pounds; and its conſumption of coals at two buſhels per hour.

Now as I have fixed the mean perpendicular height of the propoſed national reſervoirs at nine hundred feet elevation above the lower level, I will firſt endeavour to calculate the expence of commanding ſo much water at pleaſure, for the ſupport of a regulating main; and of diſtributing its influence, from the reſervoirs, through every part of the kingdom.

As the ſurpluſage of one ſuch main, confined

fined merely to the demands of irrigation, when the drought of the ſeaſon may happen to exhauſt the due proportion of humidity, would probably be of ſufficient importance in itſelf; and more particularly as any greater demand for canals, factories, mills, fiſh-ponds, caſcades, pleaſure fountains, &c. will carry with it an increaſe of income to the water works, from whence they will neceſſarily draw an accumulated profit ſufficient to juſtify additional pipes: it will ſuffice that we take this limitation of the ſubject as an ample baſis for every further extent of it.

It ſhould be held as an invariable rule in the general practice of raiſing water, or boats, in hydraulic operations, that where the riſe or fall can be brought to one ſingle riſe or fall of the land which divides the higher and lower levels of a country, the work for doing this ſhould never be divided; for it is plain that every repetition of ſuch a transfer muſt repeat a great proportion of the machinery or lockage as often as the operation is to be repeated; beſides the increaſe of attendants, and delays of repeating proceſs. In theoretic calculations it is, however, of ſome importance, for the reaſons before

before aſſigned, to eſtimate repeated, perhaps unneceſſary operations.

Hence, as Shadwell engine raiſes its water ninety feet, at a known expence, I will allow ten ſuch engines to reach nine hundred feet elevation in the propoſed national water works; and one grand reſervoir, beſides a ſet of regulating baſins, to equal each twenty-five miles of main, throughout the fifteen hundred miles that I have propoſed the extenſion of national mains, from Scotland to Cornwall.

Of the Expence.

According to the foregoing premiſes it will be perceived, that ſix hundred ſteam engines, of the value of one million two hundred thouſand pounds, conſuming two buſhels of coals each per hour, amounting to four thouſand eight hundred and ſixty-ſix and two-thirds chaldrons of coals for each ten engines; or two hundred and fifty-two thouſand chaldrons, per annum, for the whole kingdom will be demanded; which, at the good average price of forty ſhillings per chaldron, would be five hundred and four thouſand pounds for fuel.

There

There will be a demand of eighteen thousand yards of elevating main, to raise the water from the lower level to sixty grand reservoirs, each nine hundred feet above that level; this item, say, at two hundred weight of cast iron to each yard of twelve inch pipe, and five-eight metal, (which will easily bear a hundred feet column of water), amounts, at fourteen shillings per hundred weight, to the sum of twenty-five thousand two hundred pounds.

Wooden pipes, cartage, laying down, extra charges, &c. inclusive, for fifteen hundred miles of regulating main, at twenty shillings per yard, will amount to two million six hundred and forty thousand pounds. Say for sixty grand reservoirs, at two thousand pounds each, one hundred and twenty thousand pounds; and one hundred thousand more for regulating basins, buildings, &c.

Thus the aggregate cost of construction may be stated as follows:

600 Steam

600 Steam engines, each 2000l.	£.1,200,000
1800 Yards of elevating main -	25,000
1500 Miles of regulating mains	2,640,000
60 Grand refervoirs, each 2000l.	120,000
Regulating baifins - -	100,000
Allow largely for contingencies	915,000
Total coft,	£.5,000,000

It follows to ftate the intereft for which this fum may be obtained on fo eligible a fecurity; and to add the yearly charges which are attached, before the probable ballance of national gain can be afcertained or remunerated: and, as the government are all competent to regulate the rate of intereft, I will fuppofe the fum of ten per cent. per annum to be fufficient inducement. Hence the following will be approximate to

The annual expence,

Loan of five millions, obtained at ten per cent. intereft -	£.500,000
Carried forward,	£.500,000

Amount

Amount brought forward -	£.500,000
Consumption of 250,000 chaldrons of coals, at 40s. per chaldron - - - -	504,000
500 Superintendants of different descriptions, averaging 200l. inclusive - - -	100,000
Wear and tear, disappointments, casualties, new works, and contingencies - - -	396,000
Total of annual charges,	£.1,500,000

This annual expence will, I apprehend, be sufficiently powerful to govern the temperature of the seasons, and to direct elementary blessings into the coffers of the kingdom, if it should be thought proper to execute the work for public account and risque, by means of monies to be loaned on the faith of this great improvement. I will next endeavour to illustrate this lucrative prospect, by opinions and facts of the highest authority; and which must greatly overbalance the weight of my own arguments in the scale of popular conviction.

Of

Of certain Advantages which may accrue to the Government, and to its Subjects, from the Construction of grand National Water Works, as herein proposed; and from thus irrigating the steril Lands of the Kingdom by the same Means which supply our commercial and culinary Purposes.

Several of the principles which I have conceived to be most applicable and efficient towards producing the inestimable ends which we are looking to, were hinted at in my last year's plan for insulating the City of London, and bestowing all the appendant advantages of a navigable canal upon the metropolis and the surrounding country; and the theory and practice of hydraulic operations were still more enlarged upon in my general work, The Political Economy of Inland Navigation, Irrigation, and Drainage.

As I am at present, however, to aim at convincing society that my designs are practicable, I presume the facts which exist in other countries, or which are entitled to faith in this, upon the respectable state-

ments and opinions of ſuch men as Arthur Young, Eſq. Sir John Sinclair, and Mr. Middleton, will be received as admiſſible evidence in the cauſe of approximate conviction.

It is known to the world, that Mr. Young, now Secretary to the Board of Agriculture in London, made a tour of agricultural obſervation through France in the years 1787, 1788, and 1789. That tour was publiſhed in London in 1792; and I have now the pleaſure of appealing to the intereſting teſtimony it affords me on the capacities of irrigation. I do this with more heartfelt pleaſure, in as much as theſe improvements apply with intereſting propriety to many impoveriſhed ſoils in my native county of Cumberland, and the country adjacent: indeed it is a very natural inclination for men to be zealous for the proſperity of their natal ſpot, and I heartily join the Biſhop of Landaff in fervent prayer, *"that while there is an acre of ſuch waſte improvable land in Great Britain, no inhabitant of this iſland may be driven by diſtreſs," or by the inhoſpitable

* The Biſhop's preliminary obſervations to the Agricultural Report of Weſtmoreland.

perſecutions

persecutions of his relatives, "to seek a subsistence in Africa or America!"

Mr. Young says*, at Perpignan, the richest arable of the vale at Pia, sells, if not watered, at 600 liv. the minatre, (20l. 9s. 6d. per acre); but the watered lands at 1000 liv. (37l. 9s. 10d. per acre). †At Campan, lands, with water at command, sell at 600 liv. the journal (49l. 17s. 6d. per acre), of 700 cannes, (about 19,600 feet); but not watered, from 300 to 400 liv.

At Falaise, this same author informs us of ‡ a vale of watered meadows that produce 100 liv. per acre, 22 feet to the perch, (3l. 10s.)

At Montelimart, he says§, close to the town, a septier, which is one-half of an arpent of Paris, let sat $2\frac{1}{2}$ louis d'ors, or five the arpent, 120 liv. (6l. 2s. 6d. per acre.) At a distance 60 liv. with obligation to dung every second year, which is remarkable: 100 septrees, that receive the washings of the city, lets at 5000 liv.; besides 600 liv. for the winter feed of sheep.

At Avignon, he tells us, irrigation is car-

* Young's Tour to France, p. 363.
† Ibid. p. 364. ‡ Ibid. p. 364. § Ib. 365.

ried on in great perfection, by means of the waters of the river Durance, and the Crillon Canal, made only for the purposes of watering. The meadows are mown thrice a year, producing from 30 quintals of hay, at 40 to 60 the quintal, on each eymena of 21,600 feet, (7 ton 14 cwt. per acre), at three cuts. Such meadows sell, near the town, at 1000 liv. (76l. 10s. per acre); further from it, 800 liv. (61l. 5s. per acre).

In page 368, this Gentleman adds, in relation to irrigation: "It appears, that in some parts of France, particularly in the southern provinces, this part of rural economy is well understood and largely practised; but the most capital exertions are very much confined: I met with them only in Provence, and the western mountainous parts of Languedoc. In the former canals are cut, at the expence of the province, for conducting water many miles in order to irrigate barren tracts of land: in England we have no idea of such a thing. The interests of commerce will induce our legislature to cut through private properties, but never the interests of cultivation."

Again, says Mr. Young, * The diffe-

* Young's Tour through France, p. 369.

rence

rence in value between cultivation, watered or not watered, is not greater there than here, except on arid and abſolutely barren lands, on which the difference ariſing from climate is certainly enormous. Under a hot ſun, and in a comparatively dry climate, like that of Provence, ſandy or ſtony tracks, ſuch as La Crau, yield, comparatively ſpeaking, nothing; but watered, they become clothed with the richeſt verdure, and yield the fineſt crops. In regarding, therefore, the latitude of a country as an index for aſcertaining the degree of improvement effected by irrigation, theory would deceive us greatly. Water gives many other things beſides humidity; it manures, conſolidates, deepens the ſtaple or ſurface mould, and guards againſt cold; effects as obvious in a northern as in a ſouthern climate. He concludes this ſubject by recommending this moſt obvious and important object, as one of the firſt in the circle of rural economics.

Sir John Sinclair, in urging this ſubject to the attention of the members of the Board of Agriculture, of which he was then Preſident, ſays, (I preſume without contemplating any general deſign, like mine, for

raiſing water), *" at leaſt a million of acres of the waſte lands of the kingdom may certainly be brought to an aſtoniſhing height of cultivation by watering or irrigation. This great means of improvement, though long eſtabliſhed in ſome parts of the kingdom, yet in others has been unaccountably neglected. But when once that art is extended as it deſerves, the advantages to be derived cannot be eaſily calculated; for by it land is not only rendered perpetually fertile without manure, but the luxuriant crops which it raiſes produce manure for enriching other fields; and the manure obtained from that produce is another ſource of national wealth, that could not otherwiſe be looked for. Thus, ſays he, there is every reaſon to believe that the waſtes of the kingdom, if planted or appropriated for paſture lands, or cultivated for the production of grain, or converted into mead, or improved by means of irrigation, muſt neceſſarily be the ſource of infinite wealth and benefit to this country.

And if, continues he, there is a poſſibility of improving our waſtes, the means for that

* Addreſs to the Members of the Board of Agriculture, 1795, p. 20.

purpoſe

purpofe are more abundantly in our power, than perhaps in that of any other country in the univerfe. Without entering much at length into fo wide a field, it may be fufficient to remark, that there is none with fuch a capital capable of being devoted to fo ufeful and profitable an object; none where fuch a fpirit of exertion exifts, were all obftacles to the improvement of our waftes removed; none where there is fuch a mafs of knowledge on agricultural fubjects; none where fuch abundance of manures are to be found, particularly thofe of a foffil and mineral nature, without the aid of which it would be impoffible to bring great quantities of wafte lands rapidly into cultivation; and, laftly, none where, by means of a feries of excellent roads and canals, everywhere rapidly extending, fuch manures can be fo eafily and cheaply conveyed to the lands they are calculated to fertilize. Thefe are advantages for improving waftes, which no other country enjoys in equal perfection; and which would foon be the means of cultivation of a very large proportion indeed of our at prefent ufelefs territory, if full fcope were given to the induftry and exertions of the people.

Nor ought the wealth to be derived from the improvement of our waſtes to be alone taken into conſideration: the increaſe of population, and, above all, of that deſcription of perſons who are juſtly acknowledged to be the moſt valuable ſubjects that any government can boaſt of, merits to be particularly mentioned. His mind muſt indeed be callous, who feels himſelf unintereſted in meaſures, by which not only the barren waſte is made to ſmile, but of which the object is to fill the deſart with a hardy, laborious, and reſpectable race of inhabitants; the real ſtrength of a country being the fruitful nurſery, not only of our huſbandmen, but alſo of the fleets, the armies, and the artiſts of the nation. The additional number of inhabitants who might thus receive occupation and ſubſiſtence cannot eaſily be aſcertained; but, if the preſent population of Great Britain amounts to about ten millions, theſe waſtes and commons, properly improved, might be the means of adding at leaſt from two to three millions."

Mr. Middleton has thrown conſiderable lights on the great benefits which are to be derived from a regular ſyſtem of irrigation.

*Irrigation,

* Irrigation, ſays he, makes no part of the practice of a Middleſex farmer; he ſuffers the ſtreams to glide by, or through his farm, without interruption; and looks on them merely as conveying the ſurplus water out of the county. When the ſummer's heat is burning up his crops, his only hope is in an early rain: he never thinks of ſupplying the deficiency of moiſture by art. And when the winter's flood overſpreads his fields, in ſome caſes he bewails his misfortune, but dreams not of embanking the land. If his farm is exhauſted, he reſorts to the London dunghills, forgetful of the ſtreams that are running through it, loaded with fructifying particles.

The improvement of land by irrigation, ſays Mr. Middleton, is of the very firſt importance. Wherever the water of this county can be flowed over, and afterwards drained off, any kind of land, at pleaſure, be it ever ſo poor, may be laid to graſs; and by the effect of water alone, raiſed to the higheſt pitch of perfection which meadow land is ſuſceptible of. This is not only

* Agricultural Report of the county of Middleſex, p. 316,

a great

a great improvement, worked without manure in the firſt inſtance, but the land will never want any, or at leaſt not more than it will meet with in the water. The largeneſs of the produce of watered meadow is, at the ſame time, a fund for dreſſing other lands, and particularly valuable to every cow farmer. No other mode has yet procured ſuch early ſpring graſs; and the hay, when mown early, is peculiarly ſuitable for cows, being ſoft and ſucculent. As a cow paſture, no other land would ſupport half ſo much ſtock.

The produce of meadow land in this county is ten pounds an acre per annum; of the arable land, in common fields, eight pounds; light land, incloſed, thirteen pounds. Any of the foregoing ſoils would produce fifteen pounds, if watered meadow.

* Mr. Middleton farther relates, that in Hanworth Park there are about ſixty acres of watered meadow that are leſs perfectly managed than uſual; yet in the middle of September, a lot of twenty acres of this meadow was from ſix inches to a foot deep, in after graſs of the moſt luxuriant quality;

* Agricultural Account of Middleſex, p. 318.

when

when all the unwatered graſs was nearly burnt up. A piece of the ſame park, in meadow duly watered, containing forty acres, in another inſtance, had ſupported forty-ſeven horſes and bullocks, in a mixed ſtock, for three months. On the adjoining land, of ſimilar kind, manured, but not watered, the cut of the ſcythe remained ſtill viſible where the former crop had been mown. Were we to ſearch for a proper ſcite for experiments in this intereſting ſcience, or for a point of concentration from whence the benefits of experiment and example might find a centrifugal diſtribution into the world, which would do honor to the reigning prince, and add luſtre to the antient ſpirit of Engliſh munificence, I conceive the univerſe does not afford a more ſuitable field than the counties of Middleſex and Surry. The city of London is unequalled in the annals of commerce and improvement; and its ſurrounding ſuburbs and country may be rendered equally ſo in horticulture and aration. No river in the world, perhaps, receives ſo plentiful a ſupply of fructifying particles as the Thames, into which the ſewers of London are diſembogued; nor does any river in England offer an equal medium

of

of diſtribution for the fertilizing materials with which the tide is daily charged from this reſource; independent of the interior waſhings into its ſtreams, which that able agriculturiſt, Mr. Middleton, has very amply detailed.

There is no place on earth where gardeners might ſo highly improve their grounds, and eaſe ſo much of their labour by cheap and eaſy machines, as in this neighbourhood; nor is there any ſpot of the globe where the huſbandman might adopt, with greater profit, the method practiſed by the German farmers in America, in the uſe of liquid manure: theſe people ſeem to be among the firſt who have diſcovered the advantages which ariſe from this very eſſence of fertility: and from the means of commanding its diſtribution, at proper ſeaſons, along the drains and ſlopes which their grounds admit of, from a farm-yard, or reſervoir on the ſummit of the field*. All the practical farmers, where I have ſeen the uſe of this or ſimple irrigation, are not only

* See alſo Mr. Joſeph Farmer's Communication to the Board of Agriculture on this ſubject. Communications to the B. of Agric. Vol. II. p. 342.

attentive

attentive to the feafon of the year when fuch moifture is neceffary, but to the hours of the day: for if water is thinly turned upon grafs, and permitted to ftand during the extreme heat of the fun, it will fcald the roots more or lefs, and deftroy the principal means of vegetation; but if the trenches are fo conducted, that water can be at all times commanded and turned upon the grafs about funfet, permitting it to run fpeedily off after an overflow of about an hour, it will be found as effective to the full as, or more fo than, a fine natural fhower; and the next morning will prefent a fine pearly dew, although the earth in general fhould be highly parched, and a duft.

On the other hand, in refpect to clayifh or boggy land, fuch as is apt to retain the water in every hole or foot-mark of an animal, a fyftem of irrigation, accompanied with a due attention to draining, would give an equal command of the feafons by art; for perfect irrigation muft always contemplate the means of commanding water, beftowing it upon the crop, and turning it fpeedily off at pleafure. Both theory and practice confirm thefe points, and they cannot be too much imprinted on our recollection.

Mr. Middleton, in ſpeaking farther of the advantages which farms in general may enjoy at the mere expence of their individual proprietor, obſerves, that * a power, effectual and cheap, for raiſing the water in ſufficient quantity to flow about ten acres at a time, would be invaluable; as nearly all the landed eſtates in Britain might be improved by it. Should the power be acquired, he ſays, be it to work by horſes, wind, water, or ſteam, innumerable are the uſes to which it might be applied. The moſt obvious to a farm are threſhing, winnowing, cutting chaff, raiſing water for the uſe of the family and of the cattle, the grinding of malt, linſeed, and corn; but, above all, the raiſing of water for irrigation.

Forty acres of good water meadow, he adds, will ſupport, in the greateſt luxuriance, 500 Wiltſhire ewes and lambs for ſix weeks, from the middle of March to the 1ſt of May; during which time they will improve one ſhilling a week, or pay three pounds fifteen ſhillings per acre, at a time of year when all other farmers are diſtreſſed for a want of food for their ſtock. In

* View of Middleſex, p. 322.

Middle-

Middlefex it would be ftill more valuable, as five pounds worth of hay might be mown off in the firft week in May.

The beft water meadow is probably the mark of perfection in the management of a farm: it follows, of courfe, fays he, that every poffible exertion of labour, art, and machinery, fhould be employed to flow as much land as poffible.

The general features of highland meadows in the neighbourhood of London, when compared with the neighbouring commons and waftes, as well as the remarks of Mr. Middleton on a fubject for which he feems fo abundantly capable by native talent, long experience, and minute obfervation, go fully to fhew that thefe comparative extremes of fertility and impoverifhed foils, have in former days claimed nearer affinity; and they now afford a ftriking contraft as the beft convincing example of the general capacity of the kingdom: one which certainly demands the attention of the nation, when the concentrated pleafures of diffipation will permit our country gentlemen to have leifure to notice fuch a happy refult of experience, and to remunerate themfelves, through a return of its bountiful influence, in their rural concerns,

cerns, as a ſmall degree of recompence for the deteriorations of the city.

Sir John Sinclair corroborates theſe teſtimonies of the arable capacity of the kingdom, in reſpect to its waſte lands, by comparing the ſtate of the markets at diſtant periods of time*. In the reign of Queen Anne, ſays he, when half the ſtock of the kingdom were fed on commons, it is hardly to be credited, in 1710, the cattle and ſheep, ſold at Smithfield market, weighed, at an average, as follows:—Beeves 370 lb.—calves 50 lb.—ſheep 28 lb.—lambs 18 lb.

Now, it may be ſtated—beeves 800 lb.—calves 148 lb.—ſheep 80 lb.—lambs 50 lb. The increaſe is principally, if not ſolely, to be attributed to the improvements which have been effected within theſe laſt ſixty years, and the feeding of our young ſtock in good incloſed paſtures, inſtead of waſtes and commons: add again to this account, the ineſtimable benefits of irrigation.

If I may be permitted to furniſh proofs of extraordinary productions in the preſent highly improved condition of Engliſh ſtock, I may be indulged in ſtating, that at the

* Addreſs on the Cultivation of Waſtes, &c. p. 5.

Vine

Vine tavern in Stafford, where a confiderable meeting of refpectable farmers is held on market days, I had the pleafure of feeing in the month of January 1798, a fample of mutton exhibited by Mr. Princeps, of or near Litchfield, from a fheep, which the farmers prefent called his fmall breed. The weights, as then related to me, and noted on the fpot, were as follow:

	lb.
The fore quarter -	40
Hind ditto - -	32
Per fide	72
	2
The 4 quarters -	144
5th Quarter at average	36
	180lb.

The prize fheep, for the year 1799, lately exhibited among other competitors for this laudable fpecies of premium, was of the old Gloucefterfhire breed, bred and grazed by Mr. Poulton, of Crickdale, Wilts.

He was killed by Meffrs. Hifcock and

Farrow, of Reading. He meaſured ſix feet five inches and a half in girt, twenty-ſeven acroſs the back, twenty-two inches over the ſhoulders, and ſtood only twenty-ſix inches high. His depth of fat was, on the rump, eight inches, on the ribs ſix and a half inches; and his weight twenty-ſeven ſtone * and ſeven pounds.

The fat hog, belonging to Mr. William White, of Kingſton in Surry, killed 28th March 1798, was—

4 feet high,	2½ years old,
8 feet long,	49 ſcore 6lb.
9 feet 2 inches girt,	70 ſtone 6lb. at 14lb. per ſtone,
5 inches fat all over,	123 ſtone 2lb. at 8lb. per ſtone.

It was generally allowed that this hog might have been fed to double this ſize.

The prize heifer, was bred by the Duke of Bedford, and purchaſed by Mr. Hoad, of Wapping, for forty pounds.

* The ſtone of meat is 8lb. horſeman's weight, 14lb. and ſaid to be 16lb. per ſtone in ſome other caſes unknown to me.

Her

Her measure.	f.	i.	*Her weight.*	st.	lb.
Height -	4	2	Weighed -	107	7
Girt - -	8	2	Tallow -	14	0
Length -	7	0	Hide -	8	0

The prize ox, was fed by Mr. Westeart, of Buckinghamshire, and purchased by Mr. Chapman of Fleet Market.

He was	Weight.
6 feet 7 Inches high,	*241 Stone 3lb.
Girt 10 feet 4 inches,	36 Stone—4 Tallow,
Length 9 feet,	29 Stone—0 Offal.

I have before stated, that I am particularly desirous to see the introduction of irrigation into the Northern Counties, as one of the primary means of improving the extensive wastes, more especially of Lancashire, Yorkshire, Cumberland, and Westmoreland. Concerning the last of these counties I have had many conversations, and have often been opposed with the arguments of impracticability: that there was nothing there to pay

* Mr. Jefferson states the heaviest cattle which he had known to have been weighed in America, as follows:—Cow kind 2500lb.—Hog 1200lb.—Sheep 125lb. See Jefferson's Notes, p. 80.

carriage upon a ſmall canal, no land worth improvement, and that the climate was unfriendly to culture, &c.; as if gentlemen were predetermined to ſhut their eyes againſt conviction, and jogg on in the old beaten track of their anceſtors, notwithſtanding the advancement of ſcience, or conſiderations of private income.

In regard to the improvement of the Lancaſter and Ulverſtone ſands, (which *I* have no heſitation in ſuppoſing capable of reduction to a permanent ſhip channel of a conſiderable capacity, and to a vaſt acquiſition of verdant meadow, which would amply repay the adventures of ſpeculation), I am led to deſpair of ſeeing any man ſucceſsful in bringing the parties moſt concerned to view the operation as a thing practicable; more eſpecially as I have learnt, that the efforts of Mr. Wilkinſon's talents, the offers of his purſe, and the influence of his fortune, have been inſufficient to awaken the neighbouring gentlemen to a ſenſe of their own, or the national intereſt in this great undertaking.

I have, however, been at ſome pains to impreſs the idea of ſuch a ſmall interior undertaking, as ſhould afford an eaſy transfer

by

by water through the Weſtmoreland Lakes; for the diſtribution of ſea ſand as a manure for the barren heath, and an eaſier return than the preſent mode affords, for the ſlate and materials which have already forced their way to market.

In anſwer to this propoſition I have been frequently told, that it had been long aſcertained that the deſign was impracticable, or at leaſt very doubtful; that the place had been ſurveyed long ago, and the undertaking diſcountenanced; and that the country afforded nothing to carry.

I find on a later inquiry, that about twenty-eight years ago ſome gentlemen of the neighbourhood took an eye-view of the premiſes, and being perhaps, from this very ſlight attention to the ſubject, thus perſuaded at that period, the opinion of the fathers has been ſwallowed by the children. I learn that ſuch a communication, at the preſent day, would at leaſt accommodate transfer for a ſet of iron works upon the Lakes; a fine cotton manufactory; conſiderable quantities of ſlate, lime ſtone, and charcoal; beſides their reſpective returns; the articles of ſea ſand, and other manure; the ordinary occaſions of the country; the fiſhing of the Lakes and ſea; the proſpects of fu-

ture forests and agricultural productions; and the various acquisitions which result from irrigation.

* In regard to the climate of such wastes, says Sir John Sinclair, it is evidently worse for the want of cultivation. At the same time, from the insular situation of Great Britain, the climate is infinitely milder and better than in any part of the Continent, of the same latitude. It is stated in one of the reports, on the most respectable authority †, that very fine barley and oats ripen in due season on the summit of a hill in Forfarshire, elevated 700 feet above the level of the sea; and that in Invernessshire, at an elevation of 900 feet above the same level, wheat of a good quality has been grown. Hence it may be inferred, that grain, and other articles of a similar nature, may be raised to such a height upon the sides and summits of all the hills in the island; and, in regard to grass, it is well known that luxuriant crops of hay are obtained at the Lead Hills in Lanarkshire, elevated 1,800 feet above the sea. The climate of this country, therefore, can

* Address on Inclosed Lands, &c. p. 19.

† See Prelim. Observ. to the Report of Forfarshire, by G. Dempster, Esq. p. 6.

hardly

hardly be urged as an objection to the improvement of the greater part of our waftes, either for grain or grafs: as to trees, it is not to be queftioned that the *larch* grows in Italy on higher mountains than any we have in this ifland *.

In regard to the perfection to which that very ufeful tree, the larch, may be reared in Great Britain, Doctor Anderfon mentioned to me, a few months ago, a fufficient example to call for a more general plantage of them. There is one, he fays, in Scotland, of fifty-two years old, which is four feet in diameter, and one hundred and twenty feet high. This proves fufficient to eftablifh the Britifh climate as a fuitable element for this kind of culture.

In the Appalachian Mountains, in America, the larch tree grows fpontaneoufly in great abundance and fome variety. It feems to delight in a cold clayey foil, of a yellowifh caft, which abounds there in many of the deep valleys having a bleak expofure; and it flourifhes both in the watery vale at the foot, and from thence up the mountain

* See Weftm. Rep. Prelim. Ob. p. 9. See, alfo, Mr. Pontey's late pamphlet on the Culture of Larch Trees.

to its arid ſummit. When I was laſt in the Tenaſſee Country, 1793, there ſeemed to be a ſufficiency of young plants in the ſpurs of the Iron Mountain, (where the Indian Creek road paſſes from Little's Ford upon Holton River to Wautauga), to ſtock all the waſtes in Great Britain. It might be eaſy to procure them from thence at proper ſeaſons, becauſe waggons are continually paſſing from thence to the ſea ports of Richmond and Peterſburgh; and their proprietors would readily attend to the ſubject if they found an intereſt in it.

Sir John Sinclair ſays, the higher ſituated and the moſt ſteril parts ought, undoubtedly, to be devoted to plantations. There is ſcarcely, ſays he, any ſpot however rocky, or any ſoil, however unproductive, that will not yield valuable timber—an article which we are under the neceſſity of importing, at a great expence, from foreign countries. At firſt ſight it may ſeem ſurpriſing, that a ſpot that would not produce a ſingle blade of corn, will yet ſupport the ſtately pine, or ſpreading oak. But trees draw their nouriſhment from ſources beyond the reach of ſmaller vegetable productions, and by their leaves are alſo ſuppoſed to derive additional ſuſtenance

ſuſtenance from the air that ſurrounds them, or the water they imbibe. By plantations alſo, even barren ſpots may be rendered fertile.

The pooreſt ſoils, if covered with wood, from the leaves which fall, and the ſhelter they receive, improve every year in fertility; and, when the trees are ready for the axe, become, in proceſs of time, fit for cultivation.

" Many of the higher waſtes in the iſland, ſays he, may be rendered perfectly dry," (for drainage and irrigation ſhould be always found in each other's company), " and ſoon converted into excellent upland paſture. There that valuable article, fine cloathing wool, might be grown to perfection. The loftier the ſituation, and the ſhorter the herbage, the more valuable it would be; and the price which the article bears, joined to the profit of the carcaſe on which it grew, would amply compenſate for all the expence of improvement.

A much greater proportion of the waſtes of this country, than is commonly imagined, might be employed in tillage. The ſurface may appear barren and unproductive, but ſtratums may be found below, which, if incorporated

corporated with the ſoil above, may render it ſufficiently fertile. This is a practice in huſbandry which has not yet been carried in any degree, to the extent of which it is capable. It is an art pretty much in its infancy, which, when brought to its perfection, muſt be productive of the moſt important conſequences. As ſuch, it will naturally call for the particular attention of the Board of Agriculture, to aſcertain the principles upon which it can beſt be conducted."

May I not then aſk, with propriety, Where are the principles which lay ſo ſure and great a foundation for general improvement as thoſe of *irrigation?* Or, Where are the countries which may be more improved than *Weſtmoreland, Yorkſhire, and the Northern Counties,* through its offices in inland navigation, watering, and draining?

I am aware again, that if I aſk where the difficulty lies in extending a canal from the Ulverſtone ſands into the lakes, that the old hackneyed principle will be oppoſed to me, without diveſting it of its antiquated incumbrances; and that I ſhall be told that canals are impracticable throughout that ſteril country, becauſe it has no trade which is ſufficient

ſufficient to remunerate intereſt upon the monies it will require.

Now my ſuſpicions are, that this mode of reaſoning ſets out upon a falſe poſition, and muſt therefore end in fallacy. It ſeems to preſuppoſe that hydraulic genius has been long exhauſted, and reduced to ſtandard, without either allowing latitude for the progreſs of improvement, or remembering a multitude of recent proofs, that very few, if any caſes exiſt, where the expence may not be ſo proportioned to the object, as to found the enterprize upon ſome degree of rational experience, and overcome the impediments of nature through perſeverance in the paths of art.

If the country was full of commercial riches, I dare ſay the ſpirit of the nation would make no great difficulty in extending a canal from Carliſle to Newcaſtle for a ſhip of the line; but as this wealth is yet to be ſubject to the doctrines of acquiſition, and the aſſiduity of induſtry, the ſite is not ſufficiently ripened for ſuch an undertaking; and poſſibly other plans may prove equally as deceptive, when begun at the wrong end of the buſineſs, and limited by ſturdy precedent,

cedent, and by an obſtinate twenty-five ton boat.

If we were to judge comparatively of an Engliſhman and a Frenchman, from the contempt which the former is wont to beſtow on the latter, one would imagine that a native of Great Britain ſhould be aſhamed to be indebted to his inferiors for precedents of enterprize: yet it has, ſomehow or other, ſo happened, that theſe contemptible Continentals have executed an undertaking at Languedoc, which holds out precedents to Newcaſtle; and have irrigated the barren diſtrict of La Crau; perhaps a thouſand times inferior to thoſe waſte lands of Weſtmoreland, which are producing the moderate ſum of one penny per annum per acre for ſheep ſtarving; amounting, at twenty-four years' purchaſe, to the price of an American barren wilderneſs, a pitiful two ſhillings per acre *.

As I happen not, on my part, to be one of thoſe who bow down to the ne plus ultra of human invention, which the Nebuchad-

* See the Report of this county to the Board of Agriculture, or the recital in Sir J. Sinclair's Addreſs concerning Incloſures.

nezzars

nezzars of hydraulic perfection may have ſet up, I am confident enough to ſuppoſe it practicable to improve the navigation of the Cartmel and Ulverſtone ſands, or perhaps to reclaim them; to conſtruct an uſeful ſea port at their head; to extend inland navigation advantageouſly into the lakes, from Carliſle to Newcaſtle, and from Rippon to Carliſle: for although none of theſe may be practicable in reſpect to immediate commercial returns, they would ſeem to be all ſo in regard to agricultural canals and irrigations; and are indeed amply within the powers of finance, and that patience which abideth future remuneration.

In any caſe it would be a material conſideration, if ducts of irrigation only could be extended to the regulation of the ſeaſons. Yet, when we are conſidering how far the proſpect extends of improving a waſte and ſteril country, in which very few ſubjects of preſent commerce exiſt, to call in the co-operative functions of canal transfer, towards leſſening the expence of conſtructing mains for the purpoſe of agricultural irrigation, we are called upon by prudence and forethought to look forward into future periods

of

of time, and to confider what are the probable profpects of produce and material, which the nature of the country may promife to afford from its furface by means of culture, or from the bowels of the earth, by means of art and manual labour. For although the country does not admit of extenfive navigation upon a large fcale, without merchandife to fupport it by transfer, yet there are many primary confiderations of agriculture which may be affifted by the powers of finance, to extend a fmall canal into a very fteril country, upon the ftrength of its future profpects; and fuch undertakings will be found invariably to carry population and improvement along with them.

Of cultivating the Larch Tree, in Connexion with national Irrigation.

Mr. Pontey, who has lately written a Treatife on the Culture of the Larch Tree, accompanied with fpecimens of the wood produced from it, has furnifhed a demonftration of an ample refource, in this particular,

ticular, towards carrying cultivation to a degree of perfection which many proprietors would ſcarcely believe; yet, poſſibly, throughout the barren moors and heaths of the northern counties: and I am the more induced to credit the univerſality of his ſtatements, both from the luxuriance of many varieties of this tree, which I have noticed in ſome of the moſt ſteril ſoils of America, and from the abundant variety of thoſe ſoils in which I have ſeen this tree flouriſh there, in a ſtate of nature, even from the deepeſt valley to the mountain top.

Mr. Pontey ſtates the culture of theſe trees, in three-feet rows, at 4840 per acre; but prefers to plant them in four-feet rows, containing 2722 plants per acre. In the progreſs of the growth of either, it will of courſe follow, that the thriving of the trees will regulate the mean product which will ariſe from ſucceſſive thinnings of them for tranſplantation and other uſes. He furniſhes alſo an actual example of a plantation of 4194 trees per acre of various ſorts, in which the luxuriance of the larch rendered it abſolutely neceſſary to be very attentive to thinning, to prevent the other trees from being

being ſmothered by it. This plantation contained

145,000	Larch
72,500	Scotch fir
50,000	Aſh
40,000	Sycamore
45,000	Elms
600	Oaks
600	Spruce fir
30,000	Birch
10,000	Mountain aſh
400	Weymouth pine
200	Horſe chesſnut
Total 394,300	Trees.

It may afford both ſatisfaction and occaſional data to ſtate, that the trees from which the intereſting ſpecimen of larch wood, which accompanies Mr. Pontey's book, was taken, were of about thirty-five years growth, containing about 28½ feet of timber each, or 199 feet in ſeven trees, produced by a thin ſoil, with a looſe bottom of reddiſh yellow ſand.

If, by way of example, we take 100 acres of Weſtmoreland ſheep-walk, ſuch as Sir

Sir John Sinclair and the Bishop of Landaff have stated, at a rent of one penny per acre, at thirty years purchase, we must call its present value 12l. 10s. Add to this, the sum of 1000l. for fencing and planting; which corresponds with Mr. Pontey's allowance. Each lot of one hundred acres of new plantation completely fenced, would thus be worth 1012l. 10s.; which sum, placed at compound interest for thirty-five years, would amount to 5585l. within a few fractions.

Now if we take the plantation of 100 acres to be in four-feet rows, as Mr. Pontey recommends, there will be 2722 plants to each acre of ground, amounting to 272,200 plants per 100 acres.

And, if we suppose only one third of these trees to come to maturity in thirty-five years, agreeable to the specimen of larch wood exhibited with Mr. Pontey's book, and allow the other two thirds only to equal the cost of attention and repairs of fencing, &c. (which, it is presumed, will be greatly exceeded by the transplanting and other mean profits in the progress of thinning and culture) there will be ultimately

matured, in this time, the quantity of 90,733 trees. And, as we may allow each feven trees to yield 200 feet of timber, the produce of each lot of 100 acres will be 2,512,200 feet of timber.

In this way of reckoning it would follow to ftate the value of this timber, in order to come at the produce of fuch land by planting it; but as I am not informed on this point, and am without the means of reference, I will adopt Mr. Pontey's method of computation.

This gentleman admits a tract of barren land, fo termed for its bleaknefs, to yield not lefs than 125l. per acre in ftanding trees of thirty years growth, valued at 1s. 6d. each, after making every requifite deduction for deficiency and expences: and, according to this method of computation, we may, I prefume very fairly, ftate an account of the outgoings and profit upon a hundred acres of Weftmoreland fheep-walks, employed for thirty years in larch plantations, as followeth:

Value of 100 acres land, yielding 1d. per acre rent, at thirty years purchafe, together with

fencing

fencing and planting, to the amount of 1000l.—both at thirty years allowance of compound intereſt -	£.4375	18	4½

At the end of 30 years, ſay,

100 acres ſtanding timber, at 125l. per acre - -	12,500	0	0
Prime coſt, or value of land ſtill remaining - -	12	10	0
100 acres improved by ſhelter, valued at 3s. per acre, at 30 years purchaſe -	450	0	0
Ultimate value of premiſes	12,962	10	0
Deduct ſum laid out, and compound intereſt -	4,375	18	4½
Gain per hundred acres by planting - -	£.7,586	11	7½

Now I will venture to ſuppoſe, that if this poor barren country in the northern counties had no other improvement to expect profit from, or no other capacity than that

 of

of growing larch trees, that this is of itſelf a ſufficient inducement to juſtify the immediate conſtruction of canals; and we will, for argument ſake, look upon all other reſources out of the queſtion; and they will of courſe be conſidered a clear gain, if others ſhould ariſe unexpectedly.

I will therefore proceed to demonſtration on the ſole reſource of plantations: I will ſuppoſe that either Government, or an incorporated company, ſhall commence an enterprize on the 1ſt of January, 1801, which contemplates the cutting of canals, and the rearing of timber in conjunction, without any proſpect of remuneration till the year 1831, when both the crops of the plantation and the tolls of the canals will very certainly be ripe for retribution. I will allow the proportion of 100 acres of plantation per mile only, to be the quantity of poor land planted by the concern, ſo as to depend on ſo much territory in the aggregate, being within reach of the canal or its various ramifications.

To give the ſubject fair play, I will allow the extent of one hundred miles of main canal to be laid out in a direct line through the country, and one hundred miles of ſmall canals

canals to form its diſtributive branches: let the main canal be ſtated at two thouſand pounds per mile, and the ſmall or branch canal at one thouſand pounds per mile, both incluſive, and the account will ſtand as follows:

Outgoings upon this Operation for Thirty Years.

100 Miles main canal, at 2000l. - - -	200,000 0 0
100 Ditto branch ditto, at 1000l. - - -	100,000 0 0
20,000 Acres, fenced and planted in lots of 100 acres each, ſay 200 lots, at 1500l. each - - -	300,000 0 0
	600,000 0 0
Five per cent. intereſt upon the above for 30 years, at 30,000l. per annum -	900,000 0 0
Total principal and intereſt	£.1,500,000 0 0

State of the Property acquired at the end of Thirty Years.

20,000 Acres of land, at 5l. per acre prime coſt or value	100,000 0 0
Improved value by ſhelter, at 3l. per acre, at thirty years purchaſe, for 20,000 acres - - -	90,000 0 0
20,000 Acres ſtanding timber, at 1s. 6d. per tree, or 125l. per acre - -	2,500,000 0 0
Land with 30 years crop	£.2,690,000 0 0
Deduct the whole principal and intereſt expended, to be now paid off	1,500,000 0 0
Gain (beſides clearing the canal) - -	£.1,190,000 0 0

Thus, if we only admit the mean profits of the canal, grazing of cattle, &c. to pay the trouble of attending to the buſineſs, we find, that at the end of thirty years operation, ſubſcribers for ſhares will have been paid

paid more than ſeven and a half per cent. per annum for the uſe of their money; and will have moreover cleared the whole property of the landed eſtate and canal into the bargain.

Yet much more than this, of right, belongs to the generative faculties of irrigation. In France, Mr. la Lande ſays *, the canal of Provence draws, on one thouſand toiſes of its extent, no leſs a ſum than one million of livres per annum rent, for agricultural irrigation alone; and I can ſee no reaſon why any of the improvements of England ſhould be either leſs valuable, or more procraſtinated than thoſe of France.

I preſume I need give no farther example on this ſubject; yet it may be proper to ſubjoin the computations of a learned prelate of the county of Weſtmoreland, as an authority to keep my own works in countenance, leſt they be imputed to a viſion.

The Biſhop of Landaff, in his preliminary obſervations, prefixed to the report of the ſtate of agriculture in this county, obſerves that it may be of uſe to ſtate the pro-

* See Young's Tour, p. 368, or Des Canaux de Navigation, p. 175 to 184. Folio, 1778.

bable profit which would attend planting the waſte lands of this country with larch trees. He ſays, " a thouſand acres of this ſort of land might be incloſed with a circular wall, ſix feet in height (where the ſtones can be eaſily gotten, as they may in moſt parts) after the rate of 6s. an acre, or 300l. for the whole; 500 larches, two feet in height (ſo as to enable them to reſiſt the long graſs) might be planted on each acre for 14s.; hence a plantation of 500,000 might be made for 1000l. Now 1000l. improved at compound intereſt, at the rate of 4l. per cent. would, in ſixty years, amount to the ſum of 10,519l.; this is the accumulated loſs attending the incloſing and planting 1000 acres of rocky land in ſixty years.

The rent of 1000 acres, at 1d. per acre, is 4l. 3s. 4d. a year; in eight years, the larches would be out of all danger from ſheep; ſo that the loſs of rent ought only to be eſtimated for eight years; but 4l. 3s. 4d. a year, though improved after the ſame rate of compound intereſt, would not amount to 40l. in eight years; ſay, however, that it would amount to 81l. which is allowing more than 2d. an acre for the annual rent of the land, then would the whole expence attending

attending the plantation in ſixty years be 10,600l. I have here ſuppoſed ſheep to be ſhut out of the plantation for eight years; if it ſhould be found that ſheep will not crop the larch, and from more than one obſervation I have reaſon to believe they will not, they need not be ſhut out at all; nor in diſtricts, where nothing but ſheep are depaſtured, need any fence be made. I know the advocates for cloſe planting, inſtead of 500, would require 5000 larches for each acre; I am not convinced of the utility of ſuch planting, except where it is intended to raiſe up oaks, or other kinds of wood; but if that mode ſhould be adopted, the thinnings, after twenty years growth, would pay the expence of it.

At the expiration of ſixty years, ſuppoſe that only 250 larches remained on each acre, or that one half had periſhed, the probable value of them may be thus eſtimated. From a great many experiments made by myſelf, and collected from others, I find the annual increaſe in circumference of the larch, at ſix feet from the ground, to be one inch and one half on an average of ſeveral years; and this inference has been drawn from the actual admeaſurement of larches in different

parts

parts of England and Scotland, and of different ages, from ten years old to fifty. On this suppoſition, the larches would meaſure, one with another, ninety inches in circumference, at ſix feet from the ground. A larch which meaſures ninety inches, at ſix feet from the ground, would meaſure above ſeventy, at twenty feet from the ground; but ſuppoſing ſeventy inches to be the circumference at twenty feet, and the length of the tree to be forty feet, neglecting the remaining top; then will its ſolid content be eighty-five cubic feet, and the value of the tree at ninepence per foot above three guineas. But as the trees are ſuppoſed to be planted in an high, bleak, barren ſituation, their annual increaſe may not be ſo great as is here ſuppoſed; inſtead of being worth, at ſixty years after planting, three guineas a piece, admit that they are worth only ten ſhillings each, then would the whole plantation be worth 125,000l.; and deducting the whole expence, 10,600l. as before eſtimated, there would remain a profit of 114,400l.

The preſent value of 114,400l. to be received ſixty years hence, is above 10,000l. (intereſt

(intereſt of money at four per cent.) Ten thouſand pounds, at four per cent. purchaſes an income of four hundred pounds a year: by planting then, a barren eſtate, of a thouſand acres, is improved from 4l. 3s. 4d. to 400l. a year, reckoning the value of a reverſion as a preſent certainty. Sixty years is a great part of the life of a man; but it ought to be conſidered as nothing in the exiſtence of a nation, or even of a family, which is a little nation. The waſte lands of this and other counties are a public treaſure in the hands of private perſons; all of them ought to be converted into arable, meadow, or paſture land; which are capable of admitting, with profit, that kind of improvement: and ſuch of them as will not pay for that mode of improvement, ought to be covered with wood: the high parts, and eſpecially the ſheltered dells in the high parts, with larch, and the lower with oak, aſh, &c."

This eſtimate of the Biſhop's ſo far exceeds mine, that I truſt I ſhall be deemed very moderate; and I hope that gentlemen will be induced to try their own calculations in various ways.

Outlines

Outlines of a Canal Syſtem recommended to the Conſideration of the Counties of Cumberland and Weſtmoreland, in purſuance of the foregoing Principles.

Before I take leave of the irrigation and its relative improvements propoſed for the Northern Counties, I am prompted, by a true regard for the proſperity of my native ſpot, to recommend to its landholders in particular, and generally to its inhabitants, an earneſt attention to thoſe powers of combination which art has preſented to their aſſiſtance as the victor over difficulty: the extention of canals, the irrigation of the ſoil, and the planting of timber trees, ſhould every where combine to ſpread a general acquiſition of wealth in lieu of their barren waſtes; and it is every where practicable, even high in the region of Skiddaw. Mr. Leache's maxim admits canals into every country which has water enough to turn a mill; the improvements of France and of Devonſhire have pointed out an application of their ſurplus water to the enrichment of their ſoil; hydraulic improvements have eſtabliſhed the practibility of giving any degree of ſurplus water

water to any degree of elevation; and various inclined plains have proved, by practice, that any line of canal may be connected with its higher or lower level, (even over the top of a mountain), although water ſhould prove deficient for the waſtage of a pound lock.

In ſuch a ſtate of ſcience, what may not be practiſed by enterprize and induſtry? It remains but to calculate the expence; and even that dwindles to nothing in the preſence of unanimity. Let us then explore the field of operation; but let us alſo remember that canals for transfer and irrigation will water moſt land by keeping the higheſt convenient level.

I apprehend the firſt thing to be conſidered, in all great improvements of this kind is, what lines of direction have been aſſigned by nature; for theſe ſhould always pervade the general ſyſtem, with every aſſiſtance which art can beſtow; and nothing but ſome very partial exception will ever be ſufficient juſtification to turn nature out of her courſe.

Thus it is much eaſier to conduct a line of canal through a hilly country than a level one, and much ſafer for the adventurer; for nature

nature has ſaid in both caſes that ſhe will limit the operation in defiance of the caprice of man, or the competition of evil doers.

Now wherever nature has directed a line of communication, from one great town to another, through an interior country, and thro' a ſteril one, it becomes intereſting to the commerce of both places to join the improvement of the barren waſte with the communication of their commercial intercourſe and proſperity. The country we are ſpeaking of preſents many ſuch ſituations: as for example the following.

1ſt, A canal from Ulverſtone ſands to Carliſle, would run nearly as follows:

	Miles.
Up the river Leven, from its mouth, to the lower end of Winander-meer, a little above Newby Bridge,	4
Up Winander-meer to the mouth of the river Brathey - —	10
To Rydale Hall — — —	1
Up Rydale water to the head of Graſs-mere — — —	2
Up a brook that empties into Graſs-mere water to Townhead toll-gate,	$2\frac{1}{4}$
Carried forward	$19\frac{1}{4}$

Through

	Miles.
Brought forward, — —	$19\frac{1}{4}$
Through Dunmail rays gap to the waters of Thirle-mere —	1
Down this brook to Thirle-mere	$1\frac{3}{4}$
Down Thirle-mere to Smalthwaite Bridge — — — —	3
From Smalthwaite Bridge down Greata river to its junction with the Threlkeld branch of that river,	3
Up that branch by Threlkeld, Duddock, and Sales, to Moor End -	3
From Moor End to the Point of Partage at Mungris Dale —	$2\frac{1}{4}$
Over that Point of Partage to Caldew river where the road to Mofsdale croffes it — — —	1
Down that river to Hefket-new-market — — — —	5
To the mouth of Caldbeck-branch	1
To Sebergham — — —	2
Down Caldew river to the mouth of Roughton head-branch thereof	$3\frac{3}{4}$
To Dalfton — — —	2
And, down the remaining part of the river Caldew to Carlifle —	4
In all	52

Which

Which may, perhaps, be ſafely computed to be within *one* thouſand pounds per mile; if it were even neceſſary to cut a canal the whole length of the line.

The principal lateral cuts or branches which nature has connected with the above line of main canal (not including many ſmall and perhaps intereſting ramifications), are, 1. From Ambleſide to Penrith. 2. From Ambleſide to Ravenglaſs, by way of Coniſton. 3. From Threlkeld to Keſwick, with branches from thence to Workington, Whitehaven and Ravenglaſs. 4. From Scales to Penrith, by way of Dacre and Dalemain. But it will be obſerved, nevertheleſs, that each of theſe lateral branches runs in ſuch a direction as to meet ſome other branch, by which means a line of direct communication is formed throughout the Counties of Weſtmoreland and Cumberland, from one extreme angle thereof to another, in almoſt every direction where the moſt intereſting conſiderations of agriculture and commerce can be brought in contact, as it were, with each other; and to mutual and reciprocal advantage. In reſpect to irrigation, it is nevertheleſs pertinent to obſerve, that the ſyſtem of canals herein pointed out will, when

when applied to my propofed national fyftem, operate rather as catch-water drains, and general fewers, than as leading mains or conduits for fupplying a fuperabundant refource: they will, neverthelefs, in this regard contribute abundant facility to the general fyftem; and they can be made to act alternately, for the better command and diftribution of the water. They will, in this view, fave an abundant expence; in as much as while they equally perform the functions of transfer, they will alfo convey water from the fea or lakes, to the points at which nature may have prefented the leaft interrupted perpendicular lift or inclination, for elevating this national fluid to the back-bone of the country, and to the fummit levels of the grand refervoirs.

It follows to detail the particulars of the feveral lateral cuts or branches of navigation of which we are fpeaking; and from thefe an approximate eftimate may be obtained of the expence of extending a line of communication in any direction which is required.

1. *Canal from Amblesside to Penrith.*

	Miles.
From Amblesside to the head of the brook which waters that place -	$2\frac{1}{2}$
Thence to the waters of Broader –	$1\frac{1}{2}$
Down to Broaderwater Lake –	1
To Saint Patrick's well at the head of Ulles-water Lake – – –	$2\frac{1}{2}$
Down Ulles-water Lake to Powley Bridge – – – –	7
To Dalemain – – – –	2
To Penrith – – – –	$2\frac{1}{2}$
In all	19

2. *Canal from Amblesside to Ravenglass, by way of Conniston.*

From Amblesside up the river Brathy to a point opposite Skelwith –	2
Thence to the Three Tarns – –	2
Thence to Conniston – – –	3
Offset to encompass Conniston Lake	1
From Conniston to Dunnerdale –	$4\frac{1}{2}$
Thence to Devock Lake – –	3
Down that Lake – – –	1
To Mulcaster – – – –	3
To Ravenglass – – –	1
In all	$20\frac{1}{2}$

3. *Canal from Threlkeld to Kefwick; and thence to Workington, to Whitehaven, and to Ravenglafs by different routes.*

This branch admits of the following divifions:

1. *From Threlkeld to Kefwick.*

		Miles.
From Threlkeld to Wefcow	–	1
To Kefwick – – –	–	$2\frac{1}{4}$
	In all	$3\frac{1}{4}$

2. *From Kefwick to Workington.*

From Kefwick to Highftock Bridge		2
To Bafenthwaite water –	–	$1\frac{1}{2}$
Down the Lake to Oufe Bridge	–	3
Down Derwent river to Ifle	–	2
To Cockermouth – –	–	3
To Little Clifton – –	–	4
To Cummerton – –	–	$1\frac{1}{2}$
To Workington harbour –	–	3
	In all	20

 3. *From*

3. *From Kefwick to Waftdale-head.*

	Miles.
From Kefwick to the mouth of Grangebeck, at the head of Derwent water – – – –	3
Up Grangebeck to Styehead –	$5\frac{1}{2}$
Thence to Waftdale-head – –	2
In all	$10\frac{1}{2}$

4. *From Waftdale-head to Whitehaven.*

From Weftdale-head to the head of Liza river – – – –	2
Down that river to the head of Ennerdale Lake – – – –	3
Down Ennerdale – – –	$2\frac{1}{4}$
To Ennerdale – – – –	1
Down the river Ehen to the Bridge on the road from Ennerdale to Whitehaven – – –	3
Thence to Whitehaven round the hills – – – – –	$5\frac{3}{4}$
In all	17

5. *From*

5. *From Waſtdale-head to Ravenglaſs.*

		Miles.
From Waſtdale-head to the head of Waſtwater Lake	– – –	1
Down that Lake	– – –	3
From the Lake to Waſtdale	–	1
Down the river Irt to Stanton	–	2
Thence to Carleton Bridge	–	3
Thence to Ravenglaſs	– –	2
	In all	12

There are alſo three lateral cuts, connecting various points with this firſt main line which extends from Ulverſtone to Carliſle. They are, 1. From Conniſton down the Lake to the head of Ulverſtone ſands. 2. From Caldbeck to Baſenthwaite water; and, 3. From Orthwaite Hall to Abbey-holme.

1. *From Conniſton to Ulverſtone ſands.*

		Miles.
From Conniſton to the Hall	–	1
Down the Lake to Hawthwaite	–	1
	Carried forward	2

	Miles.
Brought forward - - -	2
To Peel Iſland - - - -	2
To the bottom of the Lake -	2
Down the river Crake to Lowick -	$1\frac{1}{4}$
To Ulverſtone ſands at the mouth of the river Crake - - -	$2\frac{1}{2}$
In all	10

2. *From Caldbeck to Baſſenthwaite water.*

From the mouth of the Beck to the Town - - - -	1
To the head of that Beck - -	4
To Orthwaite Hall on the Point of Portage - - - -	2
To Baſſenthwaite Hall - -	2
To the Lake - - - -	$1\frac{1}{2}$
In all	$10\frac{1}{2}$

3. *From*

3. *From Orthwaite Hall to Abbey-holme.*

From Orthwaite Hall down the river Ellen to Ireby - - - -	4
From Ireby to a point in the river near Bolton - - - -	1
Thence acrofs the Partage to Waverton on the river Waver - -	$3\frac{1}{2}$
Down the river to Ware Bridge -	2
Thence to Abbey-holme - -	5
In all	$15\frac{1}{2}$

There remains, under the fecond general head, one grand trading line from Milnthorpe, at the head of the Lancafter fands, to Carlifle by way of Kendal and Penrith. I will not now take into the eftimate any of the great leading points which are prefented to the eaftward of this line; fuch, for inftance, as the communications into Lancafhire, and Yorkfhire, thofe leading towards Appleby, and from Appleby and Carlifle towards Newcaftle, and into various parts of Scotland. I fhall probably find fome future occafion to take a diftinct view

of theſe ſubjects: it will at preſent ſuffice to notice the general line.

From Milnthorpe to Carliſle.

	Miles.
From Dallam Tower to the mouth of the river Ken - - -	2
To the upper end of Leven's Park	2
To Kendal - - - -	4
To Stavely - - - -	5
To the head of the Tarn - -	3
To the head of the river Ken -	2
To the waters of Hawſwater over the Point of Partage - - -	1
To the head of Hawſwater Lake -	2
To the mouth of the Lake -	$2\frac{1}{2}$
To Bampton - - - -	2
To Lowther - - - -	3
To Penrith - - - -	4
To Carliſle down the river Petteril	17
In all	$49\frac{1}{2}$

I will now proceed to recapitulate the total milage of a ſyſtem of ſmall canal navigation, which will be amply ſufficient for the improvement of the country; as well in reſpect

respect to the requisite carriage of its commerce as to those primary means of improvement, which cannot fail to give it commercial wealth, through the mediums of planting, watering, manuring, fishing, and mining.

Recapitulation.

	Miles.
From Ulverstone to Carlisle –	52
Ambleside to Penrith – –	19
Ditto to Ravenglass – –	20½
Threlkeld to Keswick – –	3½
Keswick to Workington –	20
Ditto to Wastdale-head –	10½
Wastdale-head to Whiteheaven	17
Ditto to Ravenglass –	12
Conniston to Ulverstone sands	10
Caldbeck to Bassenthwaite water	10½
Orthwaite Hall to Abbey-holme – – –	15½
Milnthorpe to Carlisle –	49½
Total distance	240

Hence,

Hence, if we make no allowance whatever for the lakes and rivers, but suppose them to be merely feeders to the canals, and allow the very ample sum of 1000l. per mile, which (estimating all circumstances) will, I presume, be fully sufficient, we shall find 250,000l. or one quarter of a million, will be enough to lead all the improvements of agriculture and commerce into every acre of those wastes with which Cumberland and Westmoreland so greatly abound. It is unnecessary here to repeat those computations which demonstrate a powerful result. The Bishop of Landaff has thrown sufficient light on that subject; and it is anxiously to be hoped, that the means which fortune has furnished to the noble Earl of Lonsdale, and to other powerful proprietors, will be so applied as to give greater abundance to the nation, and shower the blessings of a benign influence on the crowd which may be left behind them. I will not despair of this happy result; for, in spite of the busy hints of fame, it must be indeed a sad reflection to declining years, if men were to look back on their past life without pleasure, and on their approaching dissolution with that well-described terror of the Psalmist, which would hide

hide its guilty head beneath the mountain chaos, rather than encounter the terrible reflection of having lived ſhort of their power and talent to do good while they remain on earth!

HORTICULTURAL IRRIGATION.

In regard to the ſmaller ducts of irrigation, ſuch as are adapted to horticultural application, I beg leave to inſert an account of an experiment tried by me in Virginia, and communicated to Doctor Anderſon for the uſe of his ineſtimable periodical work, entitled, Recreations in Agriculture, Natural Hiſtory, Arts, and Miſcellaneous Literature. I recite this with his approbation, that this little work may be in ſome meaſure enriched by practical hints, ſuch as, I flatter myſelf, will apologize for repeating a few deſultory communications in a more collective method.

Some years ago, during a dry ſummer in Virginia, I was led from obſervations on the parching effect of the uſual mode of watering plants with a watering pot, to conſider the principle of operation upon the earth and plants relatively in a vegetative ſtate.

ſtate. I obſerved, that when this method was uſed about ſun-ſet, it had generally, but not always, a good effect in moſt kinds of ſoil, and produced a pleaſant dew upon the graſs and leaves on the following morning; but if the watering pot was too freely uſed during the mid-day heat, or even in the morning, it cauſed the earth to parch, and checked the progreſs of vegetation, until an annihilation of the vital principle was effected.

From an extenſion of this remark upon the larger ſcale of agriculture, which is afforded in the proceſs of cultivating maize, or Indian corn, I am perſuaded that, after plants in general have attained to a permanent radification, it is beſt to work the ground frequently, whether the weather be wet or dry; and, except in the caſe of tobacco, and ſuch other plants as we expect profit from through the curable condition of the leaf, I think a continual working of the ground will be found a better aſſurance for the crops than watering only.

I was ſatisfied, however, that the beſt modes of ſupplying a deficiency of rain were not yet diſcovered. The difficulty was how to ſupply the regular demands of vege-

tative

tative fucceffion through a droughty feafon, with a juftly proportioned fubftitute for the evaporated fubftance of the earth, by which it would otherwife have been fuccoured.

Hence (water being the natural element affigned to this purpofe in its fimple ftate) I had recourfe to the experiment of a fyphon made of twifted cotton.

I felected two water-melon vines near each other, in foil of the fame appearance; one of them being confiderably more flourifhing than the other. I made my experiment upon the declining vine, by gently twifting a cotton fyphon, made of candle wick, proportioned to the ftem of the plant; I then elevated a pot of water above the furface of the ground, covering it from the vehement heat of the fun with a piece of plank.

Fig. 1.

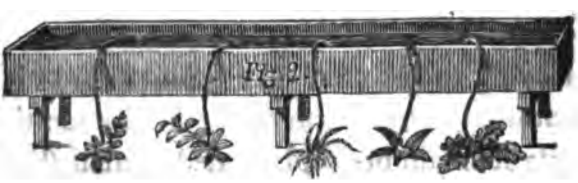
Having then wetted my fyphon, in order to communicate motion to the fluid upon the fimple fountain principle, I tied a fmall ftone to one end, as a weight to fink it when immerfed in the water; and dropping this into the pot, I paffed the other end down into the earth,

earth, by fcratching the mould gently away from the root, and giving the fyphon a fpiral direction round it, covered lightly with replaced mould.

In a fhort time the earth became moderately moiftened a few inches round the root of the plant, in which condition it continued through the heat of the day, without parching or fcalding; the fyphon fupplied the demand of the plant, and no more; a cool fucceffion took place through the effects of evaporation; and in a few days the vine became flourifhing, and outgrew its neighbour.

I have repeatedly tried this experiment with good effect, and think it at leaft capable of extenfion in a garden or nurfery.

Fig. 2.



Explanation

Explanation of the Plates.

Fig. 1. An earthen jar, containing water placed on a bench for the purpofe of elevating the water above the plant which is to be irrigated upon the fountain principle. A twifted rope of cotton or wool, proportioned to the fize of the ftem, acts as a fyphon.

Fig. 2. Differs from the above only in the fubftitution of a trough proportioned to the whole length of a bed or border; or which, if applied to agriculture, may be fuppofed to reprefent a headland ditch, or carrier trench for irrigating the whole field.

Having by this means perfuaded myfelf that I am right in refpect to the philofophical principle, it comes to be confidered, whether there are any, and by what means the beft plans may be adopted for rendering this experiment more general, and obtaining a greater number and variety of refults from divers foils and climates; and it feems to be an interefting point of inquiry, beyond a mere horticultural application, whether this auxiliary principle may not be extended, in fome fhape or other, to an agricultural benefit

nefit in the mollification of harſh and thirſty lands, on the more expanded ſcale of huſbandry?

A ſcheme which has preſented itſelf to my imagination, but which I have never had an opportunity of reducing to practice, is, to obtain, in the firſt place, a command of water upon the beſt elevated level that the ground admits of; and, purſuing this level as far as poſſible with what may be termed properly, perhaps, a headland ditch, which ſhould be as nearly ſtagnant as the circulation of fluid will permit, I think one end of a ſtraw rope, proportioned to the deſign, might be immerſed in the water after the manner of my experiment, and the other be ſpun out to the length of the reſpective lands which were deſigned for irrigation, being conducted along the ridge or higheſt part thereof, by means of a ploughed trench, ſo that the moiſture might ſpread itſelf each way by deſcent into the furrows, and without the riſk of forming gullies, which too frequently happens in red lands, as is too generally proved in America, where the lands are but partly coated with graſs, and where they are ſubject to ſudden heavy ſhowers and waſhing torrents.

This

This propoſed method can, in any event, do no miſchief; but it is ſure to anſwer one good end at leaſt in the quality of manure: for when a ſtraw rope is once entrenched for the purpoſes of irrigation, it cannot poſſibly be converted to a more profitable uſe than to let it rot in the earth for a manure.

In draining, in the county of Middleſex, ſtraw ropes, of the ſize of a man's leg, have been introduced into practice for the purpoſe of keeping open the ſmall under drains. In this caſe they are found not to anſwer, it ſeems; but I conceive there is a material difference in the effect which water will produce on ſuch a drain which is to carry off a redundancy of water, and that which is deſigned to ſupply gradually a moderate demand of moiſture: the firſt caſe would, I think, be ſubject to waſh and choak, while the latter would filter into a progreſſive decay, which would tend to enrich the ſoil.

I think the improved mole plough, which is uſed with ſix horſes for forming hollow drains, might be ſo much farther amended, as to render it a fitting implement for the furrows of this kind of irrigation. I ſhould adviſe, for this purpoſe, the addition of ſuch

wings, as would turn one half of the ſod each way, to be fixed to the hind part of the plough, leaving the mole as it is, to form a ſmooth round duct like a pipe. It appears to me, however, that for either this caſe or that of drainage, this implement might be rendered more convenient by extending the ſweep of the handle down to the mole, and connecting it with the hinder part thereof by means of a thin piece of iron, fitted to the lower part of the handle with a ſocket, and ſcrewed to the mole with a nut: this iron ſhould be ſharped ſomething like a coulter, that it may not clog the plough with the obſtructing rubbiſh of ſticks, ſtraw, rags, &c. to which all ploughing is more or leſs ſubject. This improvement of the leverage would certainly give an eaſier command of the plough.

I preſume the ſame kind of other implements will apply in trenching for irrigation, which are in uſe for trenching and cleanſing drains: all theſe are to be found in Mr. Middleton's View of Middleſex, pages 291, 292, and 293. There will be found alſo a machine for twiſting ſtraw ropes, for a purpoſe very ſimilar to that which I have ſuggeſted for irrigating farms.

As

As the expence of trenching will be nearly the ſame, whether it is applied to drainage or irrigation, we may take* Mr. Middleton's rates of labour as a criterion for computation.

The prices of draining, ſays he, have been, for

Common drains, 20 pole 18 inches deep, each drain - -	0	3	0
Principal drains, 2 feet deep, of the ſame length - -	0	5	0
Burr to each ſcore - -	0	0	2

The labourer to find tools, and keep them in repair. Drains, on the Chace, are uſually made a ſhort pole from each other.

Of artificial Springs, or Mediums of Filtration for culinary Purpoſes, White-lead Works, Paper Mills, &c. &c.

Herein before we have conſidered the immenſe advantages ariſing from irrigation, in the uſe of water in a ſaturated ſtate, for the purpoſes of canals, agriculture, and ma-

* View of Middleſex, p. 293.

chinery: it is a part of our concern to discover and communicate what may appear interesting to society in their more immediate occasions of household economy; and in such manufactures as require water in its most clear and transparent perfection. Various improvements, in these respects, have been thought of at different periods; as for example, the filtering stone, which has been long used in the West Indies, and other hot climates; porous jars, filtration through cloth or paper by descent, mediums of leather, pulverised glass, and other substitutes for nature, which ingenuity, rather than art, has been studious enough to render mysterious and profitable, without much regard to the health of the parties who were to drink the impregnated water, so that the secrets of the trade went far enough to please the eye and drain the pocket.

It seems to have been ultimately reserved to Mr. James Peacock, of Finsbury Square, to employ art to the laudable end of imitating and assisting nature, the only means by which men should promise themselves success in those hydraulic or hydrostatic operations which involve the great interests of whole communities.

I have

I have the pleaſure of preſenting a print of this uſeful contrivance from the proprietor's plate, and of hoping that this little work may contribute to its becoming more generally known to mankind, who have everywhere a greater intereſt in its efficient application, than will readily occur to thoſe who are unaccuſtomed to dive into the detail of ſuch philoſophical topics; and I truſt the modeſty of its inventor, in reſpect to its non-introduction into extenſive practice, before much of the patent period had expired, will be now remunerated, to amount of the vaſt expence and labour which he has for ſeveral years beſtowed in rendering it complete, by the conviction of ſociety, and its general introduction into public works and national improvements. The annexed plate is a deſcription of the chamber apparatus, which is ſuited to the uſe of houſes, ſhips, &c. within the compaſs of twenty guineas expence. It occupies very little more ſpace than an ordinary filtering ſtone, but it is ſufficient for the ſupply of many families; and may, of courſe, be applied to the joint comfort and accommodation of a neighbourhood at a very reduced proportionate charge.

A comparifon of the account given of this invention by the inventor, with that which three Captains, of high ftanding in His Majefty's navy, (to whom the fubject has been referred from the Board of Admiralty) have certified, will not only prove that the proprietor's ftatement is free from exaggeration, but that the improvement is worthy of univerfal attention.

Mr. Peacock couches the fuperiority of his invention, over all others, in terms which will appear very modeft when contrafted with the official certificate, which follows them in ftrong and recommendatory language, This machine, fays he, 1ft, accomplifhes the purpofe of complete filtration by afcent of the fluid to be purified through a medium (probably that by which nature performs the fame operation) of pure gravel, of progreffive degrees of finenefs, to the minuteft particles of fand; by which means the fouleft water or other fluid becomes perfectly freed from all its impurities, without acquiring any cupreous or other noxious mineral quality, which the pumice or other common filtering ftones are juftly fufpected to communicate.

2dly,

2dly, If, from continued uſe, its operation is impeded in the ſmalleſt degree, it may be completely cleanſed in one minute with the utmoſt facility; an advantage not known to any ſpecies of filtration by deſcent.

3dly, Its operation is perpetual; and, without occupying more room than a large drip-ſtone with its apparatus, it yields a pure and conſtant ſtream of more than three hundred gallons in every twenty-four hours. This circumſtance evidently puts it far above all compariſon with any filter hitherto attempted.

The advantages of cleanſing fluids, particularly water, ſays he, need not be enlarged upon. Clean linen, clear food, pure beverage, and the conſequent health and comfort of the inhabitants of great cities, are materially concerned; but the ſeaman, who is confined in diſtant and hot climates to the conſtant uſe of water abounding with inſects, animalcules, and a variety of impurities, which render it diſguſting and frequently noxious, muſt acquire by this means an invaluable benefit. It is with confidence, derived from long, expenſive, and repeated trials of its efficacy, that the inventor now reſpectfully offers this machine to the pub-

lic; convinced that it is powerfully and effectually applicable to promote the health, the comfort, and the convenience of mankind.

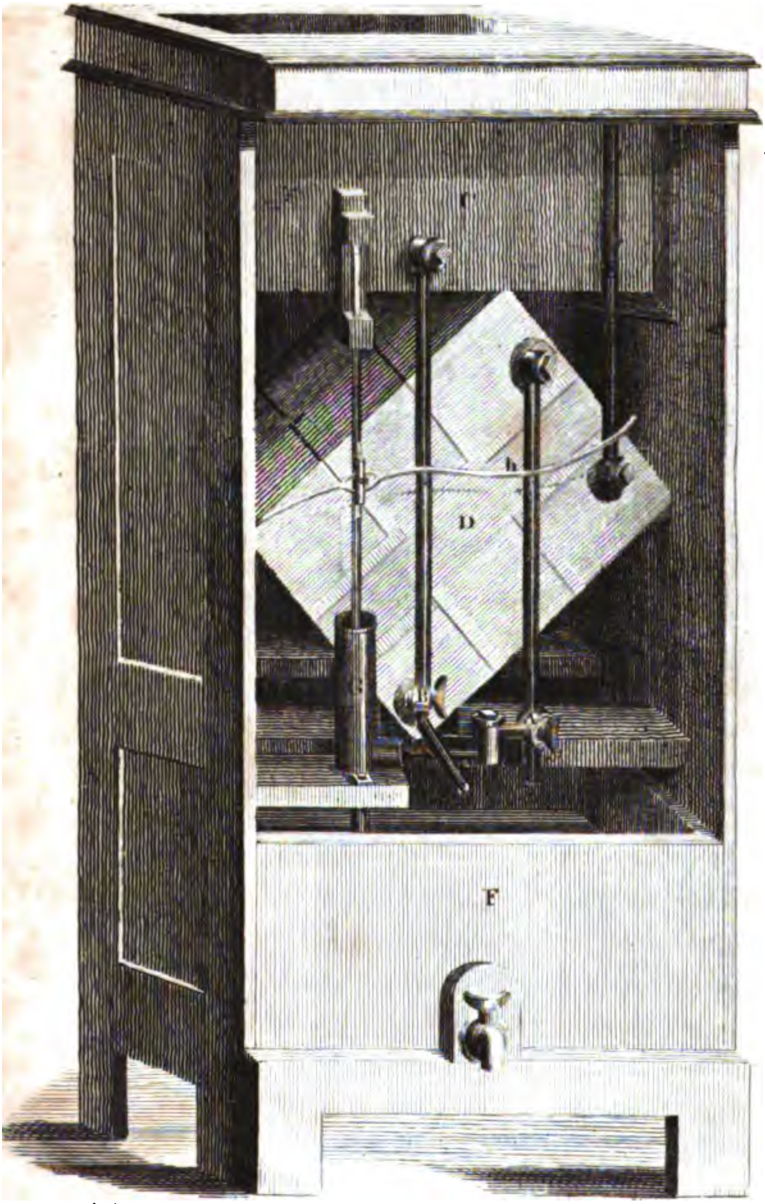
Such is the ſtatement of the man intereſted. I preſume the following independent teſtimonial will ſupport my poſition: "We the underſigned do hereby certify, that in obedience to an order of Sir Peter Parker, Bart. Admiral of the White, Commander in Chief, &c. &c. &c. That we have this day been on board his Majeſty's ſhip Vengeance, and cauſed the neceſſary experiments to be made to aſcertain the utility of a machine for purifying water by filtration.

And we give it as our mature opinion, that the machine for filtration of water fully and completely performs all that the maker promiſes in his deſcriptive pamphlet of it. And that in one inſtance we found its excellence to have exceeded his report of it, for we ſaw the filtration performed at the rate of a gallon in two minutes, or ſeven hundred and twenty gallons in twenty-four hours. And we beg leave to recommend it as a moſt uſeful machine, and to expreſs our wiſh for its common uſe in the navy, particularly in long voyages,

Given

To face Page 281

FILTERING MACHINE.



Invented by James Peacock Esq.r

Given under our hands, on board the Vengeance, Spithead, July 22, 1799.

(Signed)

T. M. Russel, Capt. of the Vengeance,
Edw. Bowater, ——— Magnificent.
Tho. Larcom, ——— Lancaster."

Mr. Peacock has added to this plate the following *Directions for using the Filtering Machine.*

1st, Let the handles of the cocks, A and B, be in a vertical position.

2dly, Let the upper cistern C, be supplied with turbid water, either by hand or by a ball-cock, from the main or some adjacent reservoir, &c.

3dly, The turbid water will then pass into the lower part of the filtering-chest D, and after expelling the air therefrom, by means of the pipe E, will ascend through the gravel in the said chest, and run therefrom in a purified stream into the bottom cistern F; from whence it may be drawn for use.

4thly, If it shall be intended to obtain in a large reservoir the full produce of the machine by keeping it constantly in action, a pipe must be fixed to the cistern F, within two

two or three inches of the top thereof, to convey the filtered water into the ſaid reſervoir.

5thly, When the operation of the machine is ſtopped or becomes languid, the gravel muſt be cleanſed in the following manner, *viz.* Turn the handles of the cocks, A and B, to a horizontal poſition; place a bucket, &c. under the cock B; and work the pump G, by the lever h, until the water comes out nearly the colour it was of when put into the ciſtern C.

6thly, Then reſtore the handles of the cocks to their firſt poſition, and the filtration will re-commence and continue as at firſt, until it ſhall be found neceſſary to repeat the operation of cleanſing the medium.

N. B. Whenever it may be neceſſary to ſweeten fetid water by an admixture of powdered charcoal, this machine will be found very uſeful in ſeparating the charcoal therefrom when that has had its effect.

Machines on ſhipboard may be filled with the turbid water, by means of a large funnel through the apperture in the top thereof, until it will wet ten inches of a rule or ſtick put therein.

If a piece of bunting, &c. is put over the funnel,

funnel, or tied to the nofe of the cock by which the turbid water is introduced, it will keep out any very grofs matter, and thereby prevent the pipes being clogged.

In times of fevere froft, if the machine is expofed thereto, it will be proper to keep the filtering-cheft empty of water, to prevent injury to the pipes, &c.

This machine is exhibited at the Surveyor's Office, Guildhall, for infpection and information. I have the fatisfaction of adding that it has been highly approved by all the men of talents who have examined it:—it need not have a higher recommendation than the notice which it has received from that well-eftablifhed and truly worthy rural economift Doctor Anderfon, to whom I had the pleafure of fhewing it. I truft a better approbation need not be looked for in the whole field of hydraulic fcience.

But it is from a popular and public adoption of the fyftem into focieties of feveral families combined, or into incorporated and national water works, that mankind may be expected to derive the extenfive benefits which it is capable of adminiftering. It is admirably adapted to prevent, in fome degree, thofe excruciating complaints the ftone and

and gravel. It needs but an adoption to rescue the poor and wretched from a thousand maladies which flow from the impurities with which ordinary water is impregnated; for nature supplies the source with unceasing bounty, and philosophical gravitation wants only the aid of a governed direction to convey it every where without carriage: a property which is alone and peculiarly the province of fluids.

In France we learn, that an economy in the use of water is, in some cases, a public concern in respect to agriculture; but it is an Englishman alone who turns his attention to the cleanliness of his food, and relieves himself from disease by the wholesomeness of his kitchen. He is the first to improve the means of houshold filtration by the contrivance of a medium which assimulates its functions to those of nature, and furnishes a portable spring which may dispense a supply as pure as crystal from the rain ponds of a desert, or the washings of a turnpike. In this happy contrivance he improves his bread, his beer, his soups, his tea, his delicacies, and his medicine: he purifies them from the filth and animalcula with which

this

this fluid element is naturally charged; and, thus ſecures his health and his longevity.

I preſume that the attention of government may extend theſe benefits ſtill farther, to the comfort and increaſe of numerous citizens. It may do ſtill more—it may adopt a general ſyſtem of national filtration, ſuch as may amply remunerate revenue by increaſing public reſources and population at a very trifling rent; and it only remains to hope that able and powerful miniſters may give theſe pacific means a leiſure moment's reflection, among thoſe which ſeem to be ſo deeply concerned in the ways and means of carnage and ſyſtematic devaſtation; and that ſuch great national undertakings may furniſh the productive means of future induſtry for the armies who are to return from the harveſt of military laurels.

Of the extent of Territory to be irrigated; the probable Remuneration which may be expected from Monies laid out in National Irrigation; and, of various Ways and Means which occur.

Hitherto we have reviewed a variety of ingenious deſigns, both at home and abroad, executed by private individuals in ſome inſtances, and by public reſources in others; and we have contemplated an infinite train of intereſting conſequences which have been, and are ſtill to be, derived from works for irrigation.

This is yet, however, an infant and limited ſcience, and it reſts with us to explore a capacious field for its future expanſion in conſidering the extent of territory which it is propoſed to irrigate, the probable remuneration from monies expended in national irrigation, and various ways and means of conſtruction which are preſented.

The data which furniſhes materials for computation in theſe reſpects, are—1. The ſtate and condition of the waſte and cultivated

vated lands. 2. The amount of annual income which the nation draws from their present ſtate of improvement. 3. Thoſe exiſting practical examples which afford experienced means of calculating the rational expectations of increaſe: and, 4. The ſeveral reſources which afford capacity, labour, and pecuniary means of execution.

1. The ſtate and condition of the waſte and cultivated lands of this kingdom is now tolerably well aſcertained through the medium of the agricultural papers of the nation, and the aſſiduity of certain members of the Board of Agriculture, who have peculiar merit in this grand eſtabliſhment; and whoſe general accuracy is ſo univerſally admitted, that I ſhall think myſelf authoriſed to follow their computations for my preſent purpoſe, without regard to the mathematical corrections of Mr. Beeke; and ſuppoſing an allowance upon his calculation for the hills and dales of the country.

Theſe inveſtigations ſeem to have decided a different reſult indeed from that of ſome former geographical inquiries by Templeman and others; but if they anſwer Mr. Pitt's turn, they ſhould alſo ſerve mine:— they aſcertain a much greater quantity of

land

land in the iſland; and they have proved, beyond a doubt, that the ne plus ultra of agricultural and mechanical perfection is but an infant, which ignorance and ſelf-ſufficiency have miſtaken for a giant; whilſt effeminate luxury and enervated diſſipation have, with equal credulity, ſubſcribed to the deception.

It will be acknowledged, however, that points in which the greater number of reſpectable inquirers agree will be the moſt likely to juſtify computations ſuch as mine, if not to approximate truth; and on this account, as well as the ſuperiority of the documents which they have acceſs to, I have choſen to rely on the following ſtatements as coming nearer to certainty than any thing elſe which the progreſs of this inquiry has determined concluſively.

* Sir John Sinclair ſtates the lands of England and Wales to be,

			Acres.
Uncultivated	–	–	7,888,777
Cultivated	–	–	39,027,156
		Total	46,915,933

* Addreſs concerning the incloſure of waſte lands, 1795, p. 7.

He

He alſo ſtates the lands of Scotland to ſtand:

			Acres.
Uncultivated	–	–	14,218,214
Cultivated	–	–	12,151,471
		Total	26,369,685

From a compariſon of theſe ſtatements it appears, that England contains 20,546,238 acres of land more than Scotland contains; but that Scotland contains 6,329,437 acres more waſte land than England contains, and is therefore far behind England in point of agricultural improvement and induſtry: for England has but little more than one ſixth part of its quantity in waſtes, while Scotland has far the greater proportion unimproved and lying nearly uſeleſs; perhaps only (to uſe Mr. Young's idea), becauſe the lazineſs of mankind is ever prompt enough to convert difficulties into impoſſibilities; and ſome have reduced it to an ideal certainty that the higher climates of Scotland are a bar againſt agricultural improvements: ſuch as the example in Forfarſhire has however happily contradicted, and left us to explore the regions of chivalry in ſearch of more ſolid ar-

 guments!

guments! But Scotland has ſome conſolations that ſhould rouſe her from lethargy and ſtimulate her exertion: ſhe has more riches unimproved, and more agriculture to beſtow on her ſteril property than England has; and irrigation will be found among the moſt powerful of her means.

If we compute the improveable probability of the waſte lands of England and Wales, according to this comparative view, and by the rules which Sir John Sinclair has adopted, it will be fair and near enough our purpoſe to allow two thirds of the improveable proſpect to Scotland, and one third thereof to this kingdom.

By this method we ſhall ſtate as follows:

	Acres.
Lands incapable of improvement – – . –	333,333$\frac{1}{3}$
Ditto fit to be planted –	1,000,000
Ditto fit for upland paſture –	4,666,666$\frac{2}{3}$
Ditto fit for tillage – –	1,000,000
Ditto capable of water meadow	333,333$\frac{1}{3}$
Total allowance	7,333,333$\frac{1}{3}$
Actual quantity	7,888,777

Now

Now the incapable lands are conſidered to be of no value; the lands fit to be planted at eight ſhillings per acre produce, according to the Biſhop of Landaff's calculations; the upland paſture at five ſhillings per acre rent, according to Sir John Sinclair; the arable lands at ten ſhillings per acre rent, and the water meadow at thirty ſhillings per acre rent, both according to the laſt named author.

From hence we are enabled to make at leaſt ſome kind of rough eſtimate of the improveable condition of annual income upon the waſte lands of England and Wales alone, as follows:

Rent of upland paſture	£.1,166,666	13	4
Ditto of arable land -	500,000	0	0
Ditto of meadows -	500,000	0	0
	2,166,666	13	4
			3
Multiply this by 3 for the annual produce, and it gives - -	6,500,000	0	0
Add produce of one million of acres in plantation, at 8s. -	400,000	0	0
Proſpects of annual increaſe	£.6,900,000	0	0

Mr. Middleton has proceeded in another way to come at a ſimilar reſult in reſpect to the arable lands of South Britain. He has attempted* an eſtimate of the acres it contains, by computing the number of people employed, and their proportions of occupation in the purſuits of huſbandry; rating the inhabitants of England and Wales at eight millions.

His calculations encompaſs an immenſe field of laborious reſult, and valuable information. He ſhews the detailed ſtate of crops and appropriations, and concludes that there are but, at moſt, fourteen millions of acres in aration in England and Wales; the portions of which he rates as follows in re-reſpect to annual crops:

	Acres.
Wheat - - -	3,850,000
Barley and Rye - -	1,050,000
Oats and Beans - -	3,500,000
Clover, Rye-graſs, one Year's Ley - - - -	1,400,000
Carried forward	9,800,000

* View of Middleſex, p. 482.

Turnips

	Acres.
Brought forward –	9,800,000
Turnips and other roots –	1,400,000
Fallow – – –	2,800,000
Total in aration –	14,000,000
Hop Grounds – –	44,000
Nurſery ditto – –	10,000
Fruit and Kitchen Gardens –	50,000
Pleaſure Grounds, the unprofitable Part only – –	20,000
Paſture, Graſs Lands, and Water Meadows – –	21,300,000
Hedge Rows, Copſes, and Woods – – –	2,000,000
Ways, Waters, &c. – –	1,603,000
Cultivated – –	39,027,000
Commons and Waſtes, as ſtated by Sir John Sinclair, ſay,	7,889,000
Contents of England Wales	46,916,000

Which, according to Mr. Beake, (p. 9 of his Pamphlet, 1800) correſponds with Mr. Young's correction of Templeman.

	Counties.	Acres.	Bushels per Acre.	Deficiency of last Crop.
	Brought forward			
S.	Salop — —	890,000	20	6 2/3 in 20
	Stafford —	810,000	25	
	Somerset —	1,075,000	24	
	Suffolk —	995,000	22	8 20
	Surry — —	592,000	23	8 20
	Sussex — —	1,140,000	26	5 20
W.	Warwick —	670,000	24	
	Westmoreland —	510,000	20	7 20
	Wilts — —	876,000	22	
	Worcester —	540,000	24	
Y.	York — —	3,770,000	22	8 to 10 in 20
	Total contents	40,000,000		

As I take the materials of this table from Mr. Young's recital, without knowing the principles which guided either the calculations of Doctor Halley or Mr. Houghton, whose work I have not seen, and merely suppose it to contemplate arable land, I can form no positive opinion of its accuracy. Mr. Young himself does not consider it to be wholly infallible; but it will serve the occasion of relative proportions, and, on the supposition of Doctor Halley's having either taken the horizontal admeasurement, or essayed an estimate of what he merely considered to be capable of aration, he seems

to

to agree near enough with Sir John Sinclair and Mr. Middleton, to ſtamp their authority as a good foundation; and this baſis is ſtill farther confirmed by Mr. Pitt's adoption of this quantity, as the cultivated contents of South Britain.

Suppoſe, however, we take the amount of Mr. Young's ſtatement, 40,000,000 of acres, as the probable quantity which may derive benefit from irrigation; after deducting for the quantity of water meadow, which we may ſuppoſe to be already irrigated, ſay 5,000,000 acres. This datum will afford a net quantity of 35,000,000 acres, which we ſuppoſe to admit of water improvements by means of actual irrigation, to be hereafter introduced. But, for calculation ſake, we may ſay forty millions of acres, on a ſuppoſition of the waſte lands adding five millions at leaſt.

2dly. The amount of annual income which the nation draws from the preſent ſtate of its artificial water ways and real eſtates, with their appurtenances (perhaps excluſive of internal fiſheries, which may doubtleſs be highly improved and extended by means of national irrigation) is computed

by

by Mr. Pitt, in his Report on the Income Bill, as follows:

	£.
Landlords' rents on forty millions of cultivated acres, estimated at 12s. 6d. -	25,000,000
Tenants' profits, at 3s. 4d. -	19,000,000
Tythes - - -	5,000,000
Mines, navigation, and timber	3,000,000
Houses - - -	6,000,000
Annual income -	58,000,000

It will be recollected, that * Mr. Young estimates the people of England at twelve millions. The labour of these people are the riches of the nation, properly speaking; but, I presume, a small portion of them only can be classed as agriculturists, irrigators, and drainers: if more of them were employed in these pursuits, it would soon result in accumulated income and domestic happiness.

* Considerations on the Question of Scarcity, 1800, p. 17.

Mr.

Mr. Young* ſuppoſes that three millions of the people of England are employed in its agricultural purſuits; and that theſe three millions feed ten millions from the culture of thirty millions of acres. In this ratio, ſeven hundred thouſand perſons more would cultivate the ſeven millions of acres of waſte lands which are ſaid to exiſt in England and Wales, in a more impoveriſhed ſtate, I apprehend, than that which nature preſented them to the occupancy of man. Now if theſe lands were only raiſed to the medium produce of thoſe cultivated lands of the kingdom which are in a ſtate of aration, without eſtimating extraneous improvements, they would almoſt add the whole of the following ſum to the annual income of the nation; for a ſmall part indeed is at preſent productive:

	£.
Landlords' rents on ſeven millions of acres brought into a ſtate of culture, at 12s. 6d.	4,375,000
Tenants' profits, at $\frac{3}{4}$ -	1,093,750
Tythes, at $\frac{1}{5}$ - -	875,000
Increaſe of income from the culture of waſte lands, without irrigation - -	6,343,750

* Conſiderations on Scarcity, 1800, p. 76.

This ſtate of culture, according to * Mr. Young, would feed 2,333,000 people; that is, 1,630,000 perſons more than what would cultivate ſuch an extent of territory, might be fed by it at home, if the arrangements of domeſtic economy would make their native ſpot more intereſting and certain to them than the inducements to emigration. But, it is preſumed, that irrigation might do much in addition to this; beſides, its capacity to afford immediate reſources from future proſpects. It is certainly a neglect that we ſhould greatly lament, and a deficiency which we ſhould ſpeedily ſet about to remedy, when we reflect that waſte lands in Weſtmoreland are rented at a penny an acre for the ſtarvation of ſheep †; while the attentions of agriculture, irrigation, and drainage might ameliorate their ſoil; coat them with warm manure; improve their climate; facilitate their conveyance; bring many new reſources to market; cover them "with numerous herds and flocks; cauſe them to

* See Conſiderations on Scarcity, &c. 1800, p. 76.

† See the Agricultural Report of Weſtmoreland, or the recital thereof in Sir John Sinclair's Addreſs concerning Incloſures, 1795, p. 5.

wave

wave with luxuriant crops of grain;" clothe them with general verdure, and adorn their ſummits with ſtately foreſts.

3dly. Thoſe exiſting practicable examples which afford experience and means of calculating the national expectations of increaſe, through the medium of irrigation alone, have been curſorily reviewed in our progreſs through this inquiry.

It follows, to collect a few of the facts to a focal point of recapitulation, that we may take proofs of what has been done and perfected in various inſtances and countries, as the beſt aſſurance of what may be performed in this by a perſeverance in ſimilar operations.

* The richeſt arable land in the vale of Pia, in France, ſells at 20l. 9s. 6d. per acre, if not watered; but if watered, it ſells at 37l. 9s. 10d. per acre. This is a difference of 17l. 0s. 4d. per acre in the value of lands, which is to be placed ſolely to the credit of irrigation.

At Campan, lands, having water at command, ſells at ſix hundred livres the journal (49l. 17s. 6d. per acre) of 700 cannes (about 19,600 feet); but not watered, from 300 to

* See p. 211, or Young's Tour, p. 364.

400 livres. This ſeems to place to the credit of irrigation a ſum equal to half the value when the improvements are made on the inferior priced lands of 300 livres value per journal of 700 cannes, and muſt be called a gain by irrigation of 24l. 18s. 9d. per acre.

At Falaiſe, a vale of watered meadows produces annually 3l. 10s. per acre; but we have not here the ſcale of compariſon.

At Montelimart, an acre cloſe to the town lets at 120 livres (6l. 2s. 6d.) per acre; but a diſtance off at 60 livres. This is a difference of 3l. 1s. 3d. per acre per annum, which ſeems to flow from irrigating the land with the liquid manure or waſhings of the city.

At Avignon, watered meadows ſell at 76l. 10s. per acre near the city: at a diſtance from it they ſell at 61l. 5s. per acre. This is a difference of 15l. 5s. per acre gained by irrigation.

In Provence, canals are contrived for irrigating at public expence.

Thus the averaged credits of irrigation in the ſeveral examples which we have drawn from France may be ſummed up as follows:

To

To the credit of irrigation, under the head of *value*;

	Value gained per Acre.		
Vale of Pia - - -	£.17	0	4
Campan - -	24	18	9
Avignon - -	15	5	0
3	58	4	1
Average in favor of irrigation, and gained in value per acre	£.19	8	0

Which increafed value, rated at twenty-four years purchafe, gives an increafed rent, flowing folely from irrigating thefe lands, of 16s. 2d. per acre.

To the credit of irrigation, under the head of *rent*, fpecifically fo ftated;

	Rent gained per Acre.		
At Montelimart - -	£.3	1	3
Average rent at 24 years purchafe, as above - -	0	16	2
2	3	17	5
Mean gain of rent per acre by irrigating rich town and medium country lands	£.1	18	8½

Brought forward	£.1	18	$8\frac{1}{2}$
According to Mr. Pitt's method of computing income, add,			
Tenant's profit, at 3-fourths	0	19	$4\frac{1}{4}$
Tythes, at 1-fifth - -	0	7	$8\frac{1}{4}$
Average produce per acre, gained by irrigation -	£.3	5	9

In England, we have ſome proofs which afford data from a few examples of poor lands raiſed by culture to a ſtate of high cultivation. The lands near London were formerly nothing but moors in the neighbourhood of Finſbury, and little better in Mary-le-bone: they are now in a ſtate of culture affording ſuch extraordinary profits, as to render them an exception to a general rule of ſafe calculation; yet theſe lands are capable of accumulation from the helping hand of the irrigator. But we have nevertheleſs a few caſes in the country which afford reaſonable grounds for a national concluſion.

Mr. Middleton, ſpeaking of the New River, or Sir Hugh Middleton's canal, ſays that

that it has probably trebled the value of many thousand acres through which it passes *.

† The produce of meadow land in this county, says Mr. Middleton, is 10l. an acre per annum; of the arable land, in common fields, 8l.; light land inclosed, 13l. Any of these lands would produce, he says, 15l. if watered meadow §.

Say thus, meadow land	£.10	0	0
Arable - - -	8	0	0
Light inclosed - - -	13	0	0
3	31	0	0
Mean produce per acre	£.10	10	0

This sum, taken from 15l. for watered meadow, puts 4l. 10s. per acre per annum produce to the credit side of irrigation.

* View of Middlesex, p. 403.—† Ib. p. 317.

§ Three crops, at 1½ load, is 4½ loads,

which, at 3l. only, is - -	£.13	10	0
Other feed - - - -	1	10	0
	£.15	0	0

 * Mr.

* Mr. Templer, of Stover, in Devon, used to rent out lands at 10s. per acre; he has raised them, by means of irrigation, to 2l. and 3l. per acre. This is an increased rent of 2l. 10s. per acre per annum, and an increased produce to the credit side of irrigation of 4l. 7s. 6d. per annum.

In the county of Westmoreland, rights of common for sheep are said to be let at so low a rate as to return only a rent of 1d. per acre for the land; which, at twenty-four years purchase, makes the value of the property 2s. per acre. The farmer's rule for estimating produce on arable property would make this 3d. per acre produce: and the common right of lands in Wales, under the same predicament, at 4d. rent, would yield 1s. per acre per annum produce; yet it is doubtful whether starvation and contingencies do not undergo this. Taking thus two of the highest and two of the lowest examples in the kingdom, and supposing the latter to draw only half the benefit of improvement from irrigation that is demanded, to bring it to Mr. Pitt's medium of 24s. $4\frac{1}{2}$d. per acre per annum produce throughout the kingdom,

* See page 176.

we

we ſhould meet half way between this gain of 12s. 2¼d. per acre produce gained by irrigating the waſtes, and the higheſt medium of gain by irrigating which we collect from Mr. Middleton's computation of the Middleſex water meadows, compared with Mr. Templer's actual improvements in the county of Devon, made ſolely by means of irrigation.

In this view, the account of gain by irrigation alone, would ſtand as follows:

	per annum per acre produce.		
Gained by irrigating Middleſex meadow - - - -	£.4	10	0
Ditto, by Mr. Templer, in Devon - - - - -	4	7	6
2 |	8	17	6
Higheſt medium produce gained per acre - - -	£.4	8	9
Say thus; higheſt gain by irrigation - - -	£.4	8	9
Loweſt medium gain by ditto	0	12	4¼
2 |	5	1	1¼
Mean gain of produce by irrigation - -	£.2	10	3½

Which is yet 15s. 5d$\frac{1}{2}$. per acre ſhort of the gain which irrigation has actually afforded in France, according to the exiſting facts which are teſtified by Mr. Arthur Young; whoſe long experience, ſkill, and official dignity, render his evidence concluſive.

Hence we deduce a ſcale for aſcertaining the mean value per acre of water when applied as a manure; and as this is perfectly independent of the moiſture afforded during the continuance of natural ſhowers, and ſhould, by every poſſible means, be treaſured up from every ſource, ſo that it may be diſpenſed with an uniform hand through every droughty ſeaſon, in the juſt proportion which the functions of vegetation requires, it of courſe applies to every acre in the kingdom, whether high or low, which can be brought into a ſtate of cultivation by art.

But that I may not be complained of for exaggeration, which may very naturally be expected from men who are not accuſtomed to think and calculate upon a national ſcale, I will compute the probable gain on an equal number of acres to that of the actual cultivation which Mr. Pitt has adopted as a baſis for the income tax; leaving others, however, as well as myſelf, to make future practicable

practicable deductions, as they may be found expedient, from this approximate datum of moderate allowance and rational poſſibility.

Say then that the poſſible gain upon forty millions of acres, contained in England and Wales, might, by means of water manure applied at ſuitable ſeaſons, yield an increaſed produce of fifty ſhillings per acre, and it proves the locked-up reſources of the nation to amount, in the ſingle item of irrigation by way of manure, (without calculating its various other uſes in the buſineſs of irrigation, watering cities, turning mills for a thouſand kinds of labour-ſaving machines, feeding fiſh ponds, pleaſure fountains, baths, moats, daries, ſtables, farm yards, dye houſes, breweries, tan yards, &c. &c.) to the ſurpriſing ſum of one hundred millions per annum.

Now ſuppoſe the national attention to be awakened to only one tenth part of this extent, or that one acre in ten were to be brought into a ſtate of irrigation, it would greatly overgo the amount of ten millions of pounds income per annum; becauſe, in this caſe, the moſt ſuitable lands for the higheſt improveable condition would not only be choſen for the ſcite of operation, but the charges of elevation and diſtribution would

be ſunk to about the level of the new river canal, and the greater proportion of the annual expence woul be abſorbed in the reduction of height and mains.

It will be recollected that I have computed the annual expence of a national main, &c. at one and a half millions for an extent of fifteen hundred miles upon national account, as a mere regulating waterwork, which would at all times, I think, be ſufficient to ſupply the ſurplus demanded for regulation; and, is probably a liberal allowance for diſburſements, which can only be ſtated at an approximate computation.

Engineers will readily perceive that this idea is intended as an average which is ſuppoſed equal in expence to the detail of open and cloſe work, ſmall and large pipes, canals, baſins, regulating locks, reſervoirs, air-veſſels, ſafety-valves, &c. which items could only be preciſely aſcertained by an accurate inveſtigation, and by profeſſional means. And it will be alſo underſtood, that I do not mean this work to interfere with individual rights, or with their works; I only mean that the nation ſhould undertake to ſupply its never-failing reſources to the full extent of all its demands, and to the comfort and advantage

advantage of all its ſubjects, who would be thus furniſhed with the ample means of paying a moderate rent for ſuch an endleſs bounty by the profit of converting it to their various occaſions.

Neither do I mean that the national purſe ſhould be touched for the means of execution. In the idea there certainly reſts a public property in reſerve, which is yet untouched, and may be amply uſed to the advantage of all men: I will not preſume to dictate ways and means—I will only ſuggeſt them. I have no doubt of the national right, and I think the ſpeculative property an object of infinite profit. The day is not far paſt when the caſh of Amſterdam would have ſeen day-light upon ſuch an occaſion; and, if the national faith and ſafety is no ways lowered in the opinion of the commercial world, I think the conjecture would prove real that the ſame gold and ſilver which formerly ſhined in coin, would again make its appearance in a more profitable way than in the melting pot of a goldſmith.

Whether, however, the nation ſhall draw from this reſource a clear annual production of five millions, or one hundred millions, ſeems to reſt entirely in their ſpirit and at-

tention to the ſubject; for there appears to be little, if any doubt, that the ſingle reſource of irrigation is fully competent to this ſupply.

It will probably be objected, that I have allowed too ſmall an eſtimate for annual expence. I admit it: theſe things are to be taken into a comparative glance, which can only be caught by the eye which is accuſtomed to explore them; and when it is conſidered how many great productive branches are untouched in this computation; (not to ſpeak of their infinite generative relations), it will be found to end about the ſame mark, and will produce always in proportion to the quantum of the means that are employed.

If the nation were to take upon them the univerſal operation of all the water works in the kingdom, I grant it that ſome millions per annum muſt be added to the account of diſburſements; but when it is conſidered that immenſe works of this nature are already in exiſtence, and maintained at the ſpeculative expences of individuals who reap high profit from ſuch, it will be alſo ſeen that theſe would form improved branches of the national ſyſtem, and that innumerable ramifications would be added throughout

every

every acre of the iſland, promiſing ſimilar gains to the ſpeculator, annual rent to the national works, and ſtill greater ſuperiority to the agriculture, manufactures, and commerce of Great Britain.

When we recur to former computations on the culture of the *larch tree, in the ſyſtem of irrigation for the Northern Counties, where there is abundance of waſte land, what may not be inferred from it? It affords a production of itſelf which co-operates to render agricultural irrigation of great and eſſential uſe. But it does more than this in reſpect to the larger arteries of irrigation: it facilitates the immediate conſtruction of valuable canals, on the credit of thoſe future productions; and it thereby opens the road to riches through the means of agricultural irrigation, ſea ſand, and other manures, while it every where ſpreads culture and population, and returns its reſults to the mutual advantage of water conveyance and the increaſe of interior wealth. Nor are theſe counties alone in regard to particular advantage; for moſt other parts of the kingdom afford ſome peculiar ſubject for facilitating the avenues to irrigation.

* See p. 238 to 251 herein before.

In

at whatſoever point of the compaſs, afford a cheaper power to great extent; many ſtreams and ſprings lay high enough to be conducted by trenches along the ſides of the hills and mountains as feeders to the national mains; the deſcending rains may be collected in the ſame way by catch drains; and many of the boggy ſummits may be ſo ſapped and drained as to draw from their interior ſprings a very material ſupply, while much more may be raiſed from wells dug in elevated ſituations and diſcharged by chain pumps. Lifting wheels of various deſcriptions may be ſucceſſively applied to return a conſiderable part of the deſcending ſtreams into canals upon a higher level; but, there is one exiſting ſource of conſiderable power which might afford a rent to the proprietors as an auxiliary to the national works: water might be conducted to every working ſteam engine in the kingdom, and a little additional expence might enable each to huſband its ſpare time to the uſe of national irrigation.

4. The ſeveral reſources which afford capacity, labour, and pecuniary means of execution, are neceſſarily ultimate conſiderations to induce us to act upon our own conviction; and, although a non-productive

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ſtock-jobbing habit of miſtaking the ſkin for the carcaſe, will be by this time expecting from me its very prompt *cui bono* of ſuperficial arithmetic, men of deliberate reflection will very cheerfully accompany me a little farther on the road of impreſſive illuſtration and ſolid example; for thoſe who undertake to think ſeriouſly for their country's good, and ſeek to lay a permanent baſis of finance, will agree with me, that to ſupply an increaſed ſum of repreſentative revenue into the public coffers, and to leſſen its demands to an equal amount by fiction, are one and the ſame thing in appearance, and may be oſtenſibly laudable; but, to furniſh productive means to the nation by the culture of its latent and permanent reſources, intrinſically interwoven in the web of common gain and proſperity, is a diſtinct conſideration which leads ultimately to the death of unpopular taxation, and calls for the cooler moments of reaſon to explore the relative connexion of men and things, and the mutual ties of intereſt between government and her people.

In this progreſs of inveſtigation, I always think it a duty to ſociety to bring forward the moſt incontrovertible arguments which occur

occur to me; and where I find ideas that have been originally the refult of my own reflections, even at a very diftant period back, and which prove alfo to have occupied the thoughts of tranfcendant merit and talents, I feel no inclination to mutilate the fuperior language in which I find them clothed, in order to reap the credit of another man's labour, or to deprive the community of thofe ftrong and impreffive points which fall with double effect into the fcale of their interefts when they have been previoufly committed to paper by the pen of a more able author. In this view I have on former occafions found peculiar pleafure in furrendering the palm of diftributive labour to the writings of Adam Smith, as I now have equal fatisfaction in acknowledging the fuper-excellence of Doctor Anderfon's reafoning on domeftic economy, the faving of animal labour, and the multiplication of national wealth by the improvement of mechanical powers.

It will be recollected, that by way of approximate eftimate through the foregoing parts of this work, I have confined my computations chiefly to the extenfion of a principal national artery or main for communicating

municating water from the higheſt ſummits of the country to the reſpective regulating baſins and reſervoirs, and from one reſervoir to another; ſo that, in caſe of any and every emergency, a ſufficient head may be given to any part which may prove deficient through caſual waſtage or partial drought: and all this part of the operation I have calculated, as a public right and undertaking, by the help of machinery for raiſing the water (even 900 feet high at the greateſt poſſible expence) from the tides, lakes, and rivers, whereſoever any of them may afford an eligible ſite for transferring this inexhauſtible reſource of water from its natural lower level to a ſummit of elevation, from whence it may act in its courſe of deſcent by the mere effect of its own gravity.

It does not follow that I adviſe Government to be inattentive to the increaſe of mains, which may afterwards be required, or thoſe more eaſily-commanded ſources of irrigation, which the principles of natural philoſophy have conſigned to its pre-emptive occupancy and profit; nor would I be underſtood to deviſe the means of a progreſſive monopoly of this fluid element, for the excluſive purpoſe of public irrigation; thereby creating

creating endlefs apprehenfion, conteft, and ftrife.

I would have the component capacity of the kingdom employed to hufband every fhower of rain and ftream above the levels of the national main and its feveral branches, as a fupply for the various ramifications of individual employment throughout the whole extent of territory; leaving every man to enjoy the benefit of his own rights, in his own way, with the leaft poffible interference of the public works, yielding on all fides compenfation for unavoidable injuries; and with this reftriction only, (a conftruction which I apprehend to be infeparable from the effence and fecurity of private property, and coeval with the diftinction of *meum*) that he who would not employ that talent, over which the exiftence of focial compact had given him a preference, on this implied condition, that he fhould fo employ it, as to do neither overt nor negative injury to others, fhould feel the penalty of reverfion to the common intereft of the community.

I fhould in every cafe be lefs tenacious in refpect to the fpecific application of the mean profits which might arife from lucrative works, than of that principle of general

ral accommodation from which every member of the community derives an inherent right to the extenſion of expedient improvements for the public good.

In this view of the ſubject, it will not be ſuppoſed that I mean to ſhut up canals in caſt iron water pipes, or to run ſo mad after a ſyſtem of ditching and locking, as to overlook the advantages which may flow from a combination of their powers: numerous would be the inſtances in a national water-work, where ſmall canals would perform the transfer of a mountainous country with great profit, and at the ſame time feed the ducts of agricultural irrigation; nor would the inſtances be leſs frequent where the water-pipes would form a ſyphon, acting from ſome more elevated reſource to ſupply alternate ſegments of a canal of unequal heights, where the ruggedneſs of a country rendered an unvarying level (which ought to be our ſtanding maxim) a downright impoſſibility. Often, indeed, would the caſe occur, in a country of this deſcription, where an inclined plain might join the continued line of communication over a valley, where the eaſieſt means of obtaining water would be through a combination of

the two powers, by laying a pipe of communication with the foundation of the rail-way.

Dr. Anderſon, in his View of the Agriculture of Aberdeenſhire, has done ample juſtice to thoſe facilities of national transfer and locomotion which are effected by turnpikes and canals; nor has he omitted to intimate, in ſtriking proofs and colours, the infinity of happy reſults which have everywhere ariſen from a due attention to their extenſion into the moſt barren territories which were known to our anceſtors, and which their darkneſs and prejudices had ſtamped with the brand of impracticability in the miſt of popular perſuaſions.

The beautiful compariſon of ſimple facts which Dr. Anderſon has choſen, will, I hope, have a happy tendency in awaking the thoughtleſs from a moſt injurious lethargy, and in rouſing the manly dignity of the antient Briton from the effeminating ſhackles of a faſhionable inſignificancy. Nothing perhaps can have a more ſtriking effect upon a popular mind, which ſeems to have nearly loſt itſelf in the labyrinth of operas, routs, galas, and nightly theatres, than the cheriſhing proſpect it muſt behold

itſelf

itſelf extricated to the enjoyment of, in contemplating the progreſs of arts from the dawn of untutored invention; the progreſs of ſcience from a rude hieroglyphic; the progreſs of agriculture and commerce through the dreary waſte, the uncultivated deſert, the trackleſs courſe, the cheering footpath, the accommodating cartway, the facilitating turnpike road, and the ſtill more wonderfully powerful canal. It is to theſe indeed, and to the inventive genius of thoſe who contrive labour-ſaving machines, that mankind owe moſt of their comforts and treaſure; that commerce and navigation owe their proſperity, and cities their aſtoniſhing grandeur!—But it is time to recur to plain, ſimple facts, which need neither type nor flower of illuſtration:

* "The object of roads," ſays Dr. Anderſon, "can never be brought too often under view where improvements are propoſed, becauſe without having good roads, every exertion in other reſpects muſt be clogged with difficulties that are inſurmountable, and no progreſs can ever be made.

* Report to the Board of Agriculture on the Rural Economy of Aberdeenſhire, in 1794, p. 219.

"I am old enough," continues the Doctor, "to remember the firſt turnpike act that was obtained for Scotland; and I recollect the time when a carriage of any ſort upon wheels, on the road between Glaſgow and Edinburgh, was ſuch a rarity, that the whole people in a village went out to look at it, and the children would have followed it for a mile; and now the intercourſe between theſe two places along the ſame road is ſuch, that carriages paſs every minute. What has been the conſequence of it? The produce of every farm can be carried to market at one-tenth part of the price they formerly could be. Manures can be obtained in great quantities to many farms eight or ten miles from Edinburgh, where not an ounce could ever have been brought. A ſpirited cultivation of the ground has taken place inſtead of the languid torpor of former times: the fields are much better managed than formerly, with leſs than half the beaſts of labour. The rent of land is nearly trebled; and the tenants are univerſally more wealthy in every reſpect than before. At the diſtance of twenty miles or more from Edinburgh, where, by reaſon of the badneſs of the climate, the poorneſs of the ſoil, and the

the want of markets, the grounds were as effectually locked up from the plough as if they had been bound up by an everlasting frost: a market being now brought to their doors for corn and hay to supply the numerous horses, and other kinds of necessaries for the people who travel the road, provisions for those who afford them accommodation, and for the numerous artificers who are wanted to supply the necessaries they stand in need of, and the people who are constantly employed in making roads, repairing carriages, building houses, and other necessary operations, means have been put into the hands of the occupiers to cultivate their grounds; in consequence of which the unfavourableness of the climate has been surmounted, the barrenness of the soil corrected, and extensive fields are now under cultivation, and bearing abundant crops, which, if the former state of the roads had continued, must have remained barren heaths to the end of time.

The people in every country district, where turnpikes have not been erected, look upon them with some degree of aversion, as the money paid at these toll bars appears to be a burden on those who pay it: and those

in towns are ſtill more outrageous againſt it, becauſe they think the money there paid muſt be added to the price of the commodities they are to conſume, and muſt ultimately land upon them. They do not advert to the diminiſhed price of carriage, which will be a conſequence of theſe turnpikes, and which bears no proportion to the toll. For example, at the period alluded to, all coals were brought into Edinburgh on horſes' backs: a horſe-load at that time was two hundred weight. All coals are now brought in carts, and there are ſome of theſe coal-drivers who now bring twenty-eight hundred weight in a cart drawn by one horſe: for this he pays twopence halfpenny of toll; ſo that he brings what would have employed twelve horſes and ſix men for twopence halfpenny. The ſaving here is ſo enormous, that if it had been mentioned *a priori*, it would have been declared to be impoſſible; but the facts are inconteſtible; and though they could not be foreſeen, they are now felt on the univerſal increaſed proſperity of every claſs of people; many of whom, while they feel its influence, are unable to trace the beneficent cauſe from whence it flows."

I ſhall

I ſhall pay ſome degree of reſpect to the ways and means which have occurred to this ineſtimable and accurate obſerver in the affairs of rural economy, in regard to what concerns the conſtruction of turnpike roads; for every ſaving in theſe concerns will apply ſtill more forcible to the conſtruction of canals, which are ever to be conſidered as a ſuperior degree of public ways, rendered more infinitely competent to all great operations in conveying heavy burdens (even in a fifty-fold degree) at a very reduced expence, without conſidering how much more money is required to amend the daily cutting of carriage wheels; or computing, on the other hand, the various items of irrigation to which this very great facility of conveyance will convert every ſurplus drop of water, without incurring an additional charge. Yet it is wonderful to obſerve the very general averſion of that commonality, who are the moſt burdened of any perſons for want of ſuch, to an extenſion of theſe great national improvements on ſuch productive principles, which adminiſter comfort and plenty to the moſt needy at reduced prices, in lieu of poverty and extortion.

"There is no popular prejudice I ever met with," ſays this ſame author*, "that is ſo unreaſonable as that which prevails againſt turnpikes. In moſt other caſes the people are anxious to throw all public burdens upon the rich rather than the poor; but the caſe is directly reverſed in this inſtance. The roads are all made where no turnpikes exiſt, by the labour of the poor, for which they receive no payment; many of whom have neither horſes nor carriages ever to travel on theſe roads: but the rich, in conſequence of that labour, are enabled to loll in their carriages at their eaſe; and while they are thus cutting up the roads, contribute nothing to put them in repair. A turnpike act, (and conſequently a canál act, for that is to be conſidered as a ſuperior ſpecies of turnpike) which ſubjects theſe perſons and others who are to uſe the roads, to a tax to put them into repair, is obviouſly the moſt equitable plan for making the roads that ever could be deviſed, and ſhifts the burden, in the firſt inſtance, from the ſhoulders of the poor to thoſe of the wealthy. One would imagine

* Rural Econ. of Aberd. p. 132.

that a turnpike act, on this principle, ought to be universally a very popular thing."

Dr. Anderson recommends, as a mode of expediting these great public undertakings, that a sufficient sum of money should be borrowed, upon a mortgage of the premises, to complete the works intended at once; to begin nearest to the town, or point of production; to suffer no money to be diverted from the purpose designed; and that if any difficulty arises in borrowing the money, the gentlemen of the district through which a line of communication is to extend, would do well to consult on the risk and propriety of warranting the tolls to the amount of the interest of the money borrowed, by the joint security of all the persons interested in such line; any deficiency, in case of necessity, to be assessed upon each individual, so binding themselves in proportion to their valued rent: they themselves, in that case, to become creditors on the undertaking, to the amount of such advances, if ever they should happen, to be paid when the state of the tolls permitted it. The reasoning which applies to this kind of security, with the advantages to be expected from it, are both of them obvious.

The

The following ingenious remarks, on the importance of keeping a level in the construction of roads, are made by the same author*:

"In every line of a turnpike road the strictest attention should be paid, so to line out that road, as to keep it as nearly upon a level plane as possible; and that in laying out these roads, every other consideration should be made to give way to this one. The inconveniences that result from pulls on a road begin already to be felt; and every day's experience will tend to put this article in a more and more conspicuous point of view. At present, every one feels the necessity of avoiding great pulls, but few have their minds sufficiently impressed with a conviction of the infinite importance of small pulls. When they consider, that if the roads be once made firm and good, so as to admit of carriages going at all seasons of the year with a single horse only, that horse may go with ease upon a level road with a load, which he could not, without overstraining himself, move at all up an acclivity, even of one inch in a yard: it must follow, that if such acclivities frequently oc-

* Rural Econ. of Aberd. p. 134.

cur

cur, an univerſal diminution of ſeveral hundred weight on each load that is to be carried along them muſt take place; and if we were to attempt to make a computation of the loſs that would be thus ſuſtained by the public, it would amount to ſomething that approaches ſo near to infinity, as to appear incredible. For it is to be remarked, this loſs ſhould be made to comprehend, not only the amount of carriage of the ſurplus quantity on what is actually tranſported, but alſo the total value of things which might have been carried, and which, becauſe of this additional expence, muſt be allowed to go to abſolute waſte where they now are: for there are many articles which might be uſeful in arts and commerce, that might find a very extenſive ſale, if they could be afforded at a ſpecified price, but which, if raiſed the mereſt trifle above that, can never find a purchaſer at all. I muſt therefore beg leave to repeat it, that this is a matter of ſuch great importance, that almoſt no other conſideration ſhould ſtand in its way."

After making theſe and ſimilar intereſting remarks, the Doctor adds, "Every argument that can be uſed for the making roads, applies with ſtill greater force to the making of

navigable canals, wherever the situation is such as to admit of them *."

But he wholly depreciates the mode which hath hitherto been adopted for raising the funds that are to be employed for constructing canals, as the worst that can possibly be conceived, as being uneconomical, unnecessarily burdensome to the public, as well as its being calculated to defeat the intent, to ruin the first adventurers, to promote a spirit of gambling and speculation, which ultimately terminates to the advantage of unconcerned purchasers, who have avoided the burden of the undertaking, while others have sunk under the weight of procrastination and ill-managed difficulties. In support of this opinion, he gives two striking instances: the first in the case of the Forth and Clyde canal, which, after a long suspension of competent remuneration, returned thirty per cent. upon the very shares which had been sold out through distress; and the other in the case of an old canal in Yorkshire, which returned 500l. per annum to the speculative purchaser of shares, which cost

* Rural Econ. of Aberd. p. 136.

only

only 50l. under ſimilar embarraſſments of depreciation.

Theſe facts, he concludes, need only to be ſtated to ſhew that the whole ſyſtem is radically defective; and not only is productive of private diſtreſs, but is alſo ſubverſive of the intereſts of commerce, for the benefits of which they were formed; and that, therefore, it ought to be departed from.

There is, however, one plan which ſtrikes Doctor Anderſon's mind as an effective one, through the happieſt reſult of experience in ſeveral ſimilar caſes in this kingdom*. "It is ſimply," he ſays, "to raiſe the money for making canals, which are literally public roads, after the ſame plan as for making turnpike roads:—that of mortgaging the toll duties to be levied from them to procure money for making them.

"There is only," he continues, "this difference between roads and canals, that a

* Two caſes are cited in ſupport of this plan, *viz.* the building the bridge of Perth with money borrowed upon the tolls, which was ſoon remunerated and free; and the light-houſe built by an individual upon the Iſle of May, which returned to Miſs Scott a perpetual income of 1500l. per annum, likely to grow into a tenfold tax. See Rur. Econ. of Aberd. p. 138.

 canal

canal can in almoſt every caſe be made at a much ſmaller expence than a turnpike road, capable of tranſporting the ſame quantity of goods, and can be kept in repair at an infinitely ſmaller expence: of courſe the very moderate tolls that need to be levied at firſt, will afford a more undeniable ſecurity to the lender."

It is not eaſy to impreſs the common run of the people with the idea of creating neceſſaries, conveniencies, and even luxuries, by a little degree of contrivance; yet this is a poſition which is eaſily conceived by the analiſing eye. If the ſtate of roads and navigation had been left wholly to the bounties of nature, without the improvement of art, the citizens of London would never have enjoyed that ſolid and accommodating pavement, which muſt unavoidably have remained a dead ſubject matter in Scotland; nor would the latter have received the reciprocrated advantage which has remunerated a proſperous condition to a place ſo remote from the metropolis. If roads and canals had not arrived to their preſent ſtate of improvement, where would have been the ſtint of commerce and navigation, or the pleaſures of a Bond-ſtreet lounge? Yet theſe facilities

ties are in a mere ſtate of infancy, and afford abundant and wonderful reſources in their progreſs towards perfection. If ſuch a fanciful thing exiſts as the Philoſopher's ſtone, it ſeems only to be found by the civil engineer in the digging of canals, conſtructing of roads and water works, and extending the unlimited power of mechanics to the reduction of animal labour: there is ſcarce indeed an end which man can wiſh for, but what this moſt honourable ſcience can facilitate; even the duſt of the turnpike roads may be conquered for a very inſignificant expence, (very far ſhort of the charge of ſtupid watering carts); and from the great extent of ſpace which is hourly occupied by the buſineſs and pleaſures of the kingdom, the accumulation of revenue might be rendered very perceptible in its aggregate returns from the moſt populous highways. If an exemption from the choakings and blindings of duſt, ſtill more perceptible in its effect upon the fine four-footed animals which are daily driven in ſpeed, and very ſpeedily reduced by thirſt and perſpiration, was only farmed of government for the carriages and horſes employed in pleaſure, it would afford a very reſpectable reſource;

while

while it would prove a wonderful ſaving to proprietors, and an intereſting acquiſition of public wealth and ſtrength.

Reſuming the ſubject of roads and canals, with great truth it is ſaid by Doctor Anderſon, that *there is a maximum in all caſes of the kind—a line to which you can juſt come, and no farther. Within that line is the ſphere of poſſible cultivation: beyond it every improvement muſt be for ever ſtopped. Now no one can ſay where that line may be placed for particular articles; of courſe no one can ſay, but he himſelf may be affected ſomehow or other in a way that he cannot juſt now perceive. Let people conſider what a mortifying thing it would be to have themſelves placed beyond that line, when, by a little forecaſt on their part, they might have been far within it. There are thouſands of bulky articles of ſmall value, which, if brought within reach of market, might prove of ineſtimable value; not ſo much by the abſolute money they bring, as by enabling the owners to bring lime, and other articles of great utility, as a return carriage which could not otherwiſe have been obtained.

* Rural Econ. of Aberd. p. 140.

To

To apply then the inferences of this very able economic obſerver to the vaſt intereſts of England and Wales, it is now, and always, the appointed time to look forwards. The ſlate of Weſtmoreland (where the rights of common for ſheep are ſaid to fetch a rent of a penny per acre), may be the means of fertilizing extenſive diſtricts if the means of transfer can be ſo facilitated as to carry that ſlate to market with profit. The woods belonging to every gentleman in the county, if the lake navigations ſhall be improved and canals ſhall be extended clear of needleſs tolls, may be rendered the means of improving their eſtates, and of planting ſucceſſive woods upon ſuitable waſtes. Clay or ſtones of certain deſcriptions may poſſibly anſwer the ſame purpoſe; and, perhaps, mines may be farther diſcovered in the ſearch which will be made for theſe. The ſand and manure of the ſea coaſts may be reciprocated in return, and by this means the cold and clayey ſoils may be ameliorated, after its bogs have been drained and rendered arable by the induſtry of national irrigation. In ſhort no one can ſay what a variety of articles may in future be diſcovered among thoſe bleak and heathy wilds of the Northern Counties,

which prejudice and inexperience have deemed as impracticable in our day as the wonderful effects of the steam engine would have been declared in the most lucid days of our ancestors, or the discovery of a western world before the enterprize of a Columbus.

Among the various obstacles which impede the progress of success in the operation of canals, and which diminish the profits which are expected from them, Doctor Anderson, very justly I think, reprehends the rage for extravagantly magnificent things, greatly disproportioned to the wants and to the present circumstances of the country *.

" When a great deal of money," says he, " is expended on a canal, through which there cannot for many years be much commerce, the pontage dues are necessarily so high as to repress the trade upon it to an astonishing degree. Even at present the expence of pontage, on the canal from the Forth to Glasgow, is so high, that nearly one half of the goods that go from Edinburgh to Glasgow can be sent cheaper by land. Had it been a small canal, on which the pontage would not necessarily have

* Rural Econ. of Aberd. p. 140.

amounted

amounted to one fourth part of that per ton, the intercourſe upon it would have been a hundred times greater; and this extenſion of intercourſe would have enabled them to have lowered it ſtill much farther than that.

Better therefore to make a ſmall canal originally that ſhall be proportioned to the preſent wants of the country, and when the intercourſe becomes ſo great as to require a larger one to make the canal then larger, than to expend at the firſt a great deal of uſeleſs money, which, inſtead of benefiting, muſt tend to prove hurtful to commerce."

I think, however, we may now venture to prognoſticate, that if ſuch counties as Weſtmoreland, Cumberland, and a great part of Yorkſhire and Lancaſhire, ever enter upon a ſyſtem of ſmall canals, as they certainly are intereſted to do, they will never ſee the day when they would wiſh to enlarge them, howſoever paradoxical it may ſeem to them at preſent ſhould they be told that a ſmall canal ſyſtem will transfer more goods than a large one, although the expence of conſtruction may not perhaps exceed a third or fourth part of the former, averaging all ſituations and circumſtances.

* "The public have been precluded from receiving the benefit of canals in many cafes," adds the Doctor, "from the circumftance of our having univerfally adopted the plan of lowering and elevating boats by means of water-locks alone, which, by requiring fuch a vaft fupply of water, renders it impoffible to have a canal at all in many cafes where they would have been otherwife practicable, and in all cafes greatly augments the expence that would be neceffary if thefe could be difpenfed with; befides retarding the intercourfe by reafon of the numerous ftoppages they occafion; for as no water-lock can conveniently be made to lower at once above fix or eight feet, where a rife is confiderable, they muft occafion frequent ftoppages; whereas, in the other way, it would make little difference to lower eighty feet or eight. But I muft not now ftop," he obferves, "to detail the benefits that would in fome cafes be derived from this circumftance. Thefe would fometimes approach to infinity.

"We have farther," he fays, "been in a yet more eminent degree deprived of the

* Rural Econ. of Aberd. p. 141.

benefits

benefits of water carriage, in innumerable cafes, from the circumftance of our never having attended to the benefits that might be derived from the conveying water canals on a level through a great extent of country, as may often be done at a very fmall expence, along the fides of low ranges of rifing grounds, for very great diftances through corn countries, which would not only fhorten the diftance of land carriage of corn, &c. to market, even where the canal could not go the whole way, but alfo would, in innumerable cafes, facilitate the conveyance of lime and other manures from one part of the country to another.

* Were a method devifed for conveying loaded boats from one canal into another, without the aid of water locks—and were canals made of a fmall fize, and confequently at a cheap rate—and was the neceffary attention beftowed to carry every canal as far as it poffibly could go upon the fame level through the country in all directions, there is not a doubt but that goods could thus be conveyed at a fmall expence by water car-

* See Political Economy of Inland Navigation, &c, p. 80, 91, 95, 101, 107, 110, 113.

riage to and from almoſt every corn farm in this extenſive diſtrict *.

"To obtain all theſe benefits," rejoins this ineſtimable friend of mankind, "I would propoſe that every canal ſhould be conſidered preciſely as a public road, and put under the management of the Commiſſioners of Supply in every diſtrict, exactly as the turnpike roads are at preſent. After proper ſurveys have been made, and the practicability of making a canal in any particular diſtrict aſcertained, an act of Parliament ſhould be obtained for making ſuch or ſuch a canal, and for levying tolls, to be ſpecified in the act; the whole proceeds of which ſhould be applied, in the firſt place, for the payment of the ſums expended on making the canal, with intereſt till paid up; and upholding the canal itſelf, and nothing elſe, and extending it farther, if judged neceſſary; and after this money was paid up, the tolls on that canal to be lowered, ſo as to amount to no more than is neceſſary for keeping it in thorough repair.

For the purpoſes of internal commerce, it does not ſeem neceſſary ever to have a boat

* Aberdeen.

wider,

wider, in any caſe, than four feet; nor the draught of water above two or three feet; for as the length of the boat may be indefinite, it is eaſy to proportion that to the burden intended: of courſe, where the circumſtances are ſuch, as that the boats will not be very frequently paſſing each other, a width of five feet, and a depth of two feet and a half, or three feet at moſt, are ſufficient. Where canals of this ſmall ſize are adopted, a niche may be made at the ſide at every quarter or half mile or ſo, ſufficient to receive one boat until another paſſes, where they chance to meet.

I am aware of the objection that will here occur, on account of the great reſiſtance that would be made to boats paſſing in a canal, with ſo little vacant ſpace on each ſide of the boat; but as every perſon, in the leaſt acquainted with the laws of hydroſtatics, knows that the reſiſtance from the water would be equally diminiſhed if there was one inch depth of water only on the ſurface, as if there were a thouſand fathoms deep, this objection may be entirely obviated by laying the earth that comes out of the canal five or ſix feet back from its edge, ſo as to allow the water there to flow over the origi-

nal surface of the ground. By this means the breadth of canal wanted is obtained without any expence; so that to dig a deep canal under the pretext of widening it, for the purpose of removing the resistence, is a mere useless expenditure of money.

"As it must happen, however, that by thus widening the canal, the evaporation will be thereby augmented; to guard against this inconvenience, it will be always adviseable to make the towing path, if possible, on the North-east side* of the canal, and to plant the opposite bank all along close with willows, which by their shade will screen the canal from the influence of the sun, and by their shelter defend it from the drying effects of the South-west winds which so much prevail in this climate during the summer season.

"Near the sea, or any great town, where the intercourse must be more frequent, the breadth of the canal may be nine or ten feet, so that two boats may pass each other everywhere, having the same depth as before.

"A canal on this plan would in some measure resemble a river. The principal

* The prevalency of winds vary in different places.

trunk

trunk should be of the larger ſize; the leſſer branches, that went off to particular places, would be of the ſmaller. The expence of making a canal of this kind would be very ſmall, for little earth would require to be removed. Were a ditch, five feet wide and two feet deep, to be dug out of the ſolid to the whole depth, it could, on an average, be dug at the expence of* ſixpence a yard; but when it is conſidered, that by throwing the earth principally to the lower ſide, the water may be raiſed above the level of the ground, it will not require to be caſt ſo deep, and of courſe the expence of making it would be leſſened. This will be a large allowance for the ſmall canals; and one ſhilling per yard a full allowance for the larger, not including the expences of locks, aqueduct-bridges, &c. This is upon the ſuppoſition that they are to be carried upon the level†, following the form of the ground wherever it may lead to; but where hollows are to be croſſed, which ought never to be done but in caſes of ex-

* Prices are local: this is at Aberdeen in Scotland. W. T.

† This general rule will meet many exceptions. p. 22, one in Leach, p. 107. Liſkeard canal.

treme

treme neceſſity, an additional expence will there be incurred, as well as for aqueduct bridges, where theſe become neceſſary. Theſe expenſive works can only become requiſite, however, on the larger branches; the ſmaller ramifications which fall into theſe can ſcarcely ever require the aid of ſuch expenſive erections.

As to bridges for allowing the water to paſs under the canal, unleſs where the ſtream is conſiderable, this will not be neceſſary; for by making the towing path always on the upper ſide of the ditch, and leaving at proper places a long level on the lower bank, at the ſame height it is ever meant to riſe to, whenever ſuperfluous water, from tranſient rain or other cauſes, came into it, this would flow over theſe long levels with a calm ſilence that would never be felt.

"Were a trunk canal of this ſort carried along the rivers of Aberdeenſhire," concludes the Doctor, "the Dee alone excepted, which is too rapid, and too much confined on each ſide by mountains, eaſily to admit of it, and were leſſer canals branched off from it at every rivulet that flowed to any diſtance through a level part of the country, its improvement would be wonderfully facilitated; and

and when the ſmallneſs of the expence of ſuch erections is conſidered, and when it is alſo adverted to, that by this means the expence of highways would be conſiderably diminiſhed by removing from them all weighty carriages, this will not appear to be a difficult enterprize; for it will require much leſs money to make one of theſe canals than a turnpike road of the ſame length; and the keeping it in repair, when once made, would be, in compariſon of a road, next to nothing."

The Doctor next proceeds to exemplification of the principles which we have been tracing; but, as an examination of theſe would require a detail knowledge of the country, I ſhall content myſelf with noticing a few ſtriking particulars which may be of general uſe. He points out the various levels and places proper for branches and ramifications diverging into every quarter of the country, and ſays that nothing could be better deviſed for giving a perfect idea of the plan which ought to be adopted for forming canals of the kind he alludes to, than the parallel roads in Glenroy, near Fort William.

* "Theſe

* "These roads," he says, "are carried forward along the sides of the hills, in a direction everywhere perfectly horizontal. Wherever they come to a cavity in the hill, they there bend inwards till they find the natural level; and where they come to a river, instead of sinking down to the level of its bottom, or requiring to have a bridge directly across it to raise the ground to its proper level, they turn up the bank of the river, keeping still the horizontal direction, till they thus gradually reach the bottom of the stream; when crossing it, and altering their direction once more, they pursue the course of the stream on the opposite bank till they reach the strath, when they proceed forward in the same horizontal direction as before.

From this unaccountable work of a barbarous age, we may be taught one important lesson in regard to the conducting of canals, which seems never yet to have been adverted to; viz. that in many cases it may be practicable to carry forward a canal at less expence through a country intermixed

* Rural Econ. of Aberd. p. 146.

with

with long ridges of hills, than in thofe that are low, and in general of a fmooth furface; for even where the declivity of the rivers are confiderable, if the hills are not difcontinued, a canal upon the fame level may be carried forward very far, and cannot be interrupted by the leffer ftreams that fall into the vale, becaufe the declivity of thefe rills is fo great, that the canal requires to be carried but a very fhort way out of its direct courfe, before it finds its level acrofs it, fo as to avoid the neceffity of having aqueduct bridges there; whereas, in more level countries, thefe rivers often flow through a long courfe of level ground, which cannot be croffed without either locking down on each fide of it, or turning out of the way a great many miles before you can crofs the river upon the original level. Many benefits, however, would be derived to the country, were the conductors of canals to be in general much more parfimonious of their locks than they ufually are, fo as to endeavour to try, in every cafe of this kind, to crofs the interrupting vale and ftream upon the natural level of the canal.

It would be improper to enter in this place into farther particulars on this head, or to enlarge

enlarge on the benefits the country would derive from the opening up of a communication of this ſort, which are indeed ſufficiently obvious. The difficulty will be to perſuade moſt men that a thing which is repreſented as ſo eaſy, can in fact be literally practicable; becauſe they think if it had been practicable it would have been long ago adopted. To this objection I ſhall make no anſwer; but beg leave only to ſtate the following fact.

After tolerable roads were made through moſt parts of Scotland, ſo as to admit of their having free intercourſe with other places, Archibald Duke of Argyle and other gentlemen of that country were deſirous to open a communication between the peninſula of Cantyre and the other parts of Argyleſhire, which was disjoined from them by a rugged ridge of very high hills between which no paſſage could be found. Many ſurveyors were ſent to explore this rugged region; but all of them returned with the moſt diſcouraging report. Moſt of them ſaid that it was not poſſible to make a paſſible road at any expence for about ſeven miles of that diſtrict. Others reported that it might perhaps be poſſible; but that at the lowest

lowest estimate which could be made the expence would exceed thirty thousand pounds. This was a sum so enormous that the idea of executing it was for the time abandoned. Still however the necessity of having such a communication occurred, and it became an endless subject of conversation at the county meetings. At length one gentleman observed, it could never be done if they did nothing but talk about it; and proposed that they should try to do something. It was immediately resolved to open a voluntary subscription to make at least a beginning, and try what could be done. Fifteen hundred and odd pounds were subscribed at the meeting, and a committee was appointed to see the money expended, and to make a report how far it went. The work was begun and carried on with alacrity while the money lasted; and, to the perfect astonishment of the next meeting, they laid their report before it, when it appeared that the whole of the road was completed in the most perfect manner, and better than one hundred pounds of the money remained at the disposal of the meeting. If, before this trial was made, any person in the county had said it might be effected for fourteen hundred

 pounds,

pounds, he would have been laughed at for advancing such an absurd opinion."

A similar thing happened within my knowledge at Lumbeston in North Carolina. Near this place, upon Drowning Creek, there is a branch of that creek called the saddle-tree swamp which is narrow and passable at its junction with the creek, but widens considerably and is difficult to pass on account of the mire and thickets, till it extends some distance up into the neighbourhood. The path which crosses the mouth of the swamp is so near the bank of the creek, that in the time of freshes, or land floods, it is greatly inundated; and as people often encountered the risk of crossing this place in preference to going a round-about way, several persons had been drowned. I observed, from the formation of the land, about a bow shot from this place, that notwithstanding the impervious aspect of the thicket, there appeared to be there a more solid foundation and no great distance through the swampy part; and I proposed to fall upon some plan or other to open a new crossing place; but this was deemed to be, if not wholly impracticable, at least a very difficult undertaking. I at length proposed

that

that voluntary working parties of the neighbourhood ſhould encounter it, by way of a frolic, on Saturday afternoons, till we either ſucceeded or were tired of the experiment; and that *I* would furniſh rum. This laſt propoſition had ſufficient charms to ſet half a dozen axes at work; and we not only reduced the job under a day's work, but opened a cart-way through a better part of the woods for at leaſt half a mile beyond it.

I recite theſe caſes to ſhew how frequently that bugbear, ideal impoſſibility, deters men from undertakings of the higheſt importance to themſelves and country, when the only great difficulty is to ſet about the buſineſs with that true ſpirit and energy which is competent to remove every obſtacle that may be impeded.

Of the Ways and Means for conſtructing Works for National Irrigation.

I feel a delicacy in the taſk of digeſting a plan for carrying into execution the various works of national benefit which I have ſuggeſted; not, however, that I perceive any

great difficulty in the bufinefs, but it is enough that I am not officially employed.

Hints may, neverthelefs, be of ufe to thofe who are more immediately concerned; becaufe they may call to their recollection both variety of methods, and choice of fubject matter to be acted on.

In the progrefs of this work, under the head of *Irrigation of the Northern Counties*, I have fuggefted ways and means of operation which I think government may ufe to very great advantage, whether it is viewed as a public or private undertaking. In the one cafe they will hold the agency and profit in their own hands, by means of their officers; and in the other, they may either referve a certain portion, or moiety perhaps, of the intereft which fhall annually arife, or they may fell or farm out the privilege of national irrigation upon fpeculation, on the faith of a parliamentary guarantee. This, I apprehend, without infringing private rights of property, may be legally granted for the confiderations of accumulating revenue and national ftrength.

Doctor Anderfon feems to object to any other mode of extending canals than that which has been adopted for the fupport of

turnpikes. His motive is certainly a laudable one; and it ſhould heartily meet my approbation if it were practicable to carry his plan into execution: the queſtion ſeems to reſt chiefly in the ſpirit of the times, and will of men in power.

Private means are often adequate to very great undertakings; but there are many inſtances where ſucceſs muſt depend entirely on a combination of powers and circumſtances, or where the ſupreme intervention of the community becomes eſſential. In favour of national irrigation, the interruption which ſmall poſſeſſions might impede in the way of ſyſtem, and of improvements of the greateſt conſequence to all, is a ſtrong argument; for it will be always found, in practice, that one obſtinate man may do a great deal of miſchief, or prevent a great deal of good to his neighbours; and that if men are not previouſly bound, by their joint agreement, to take a fairly-aſſeſſed compenſation for unavoidable injury to individuals, (a method which I would always recommend in the extenſion of water works, roads, and canals), the generality are prompt to ſtand out for an extortionate remuneration which procraſtinates the buſineſs intended; and if it ſo hap-

pens that the law has been ſilent on this point, the undertaking muſt either ſubmit to a groſs impoſition or ſtand ſuſpended; although the refuſing party is aware that his eſtate muſt become eventually improved in value by the very completion which he withholds his conſent from.

Theſe are circumſtances, among others, which ſeem to indicate the propriety of undertaking works of national irrigation on the ſtrength of the public purſe, and returning the annual profits by a rent ſtipulated for the reſpective quantums of benefit, without intruding the odious term *taxation* upon the ear which feels ſorely galled.

In executing the work, I preſume, if undertaken for public account and riſk, there would be no impropriety in employing the ſoldiery who may have leiſure for ſuch labour. The Spaniſh ſoldiers avail themſelves of the king's extra pay for their labour in works of public utility, and this is deemed highly honourable. It fits them moreover for the duties of their profeſſion; and thus familiarizes them to many fatigues of a campaign, which are rendered lighter by habits of induſtry and the acquirement of profeſſional knowledge. In reſpect to the

ſoldiery who return on the eve of peace, it would be anticipating a means of ſubſiſtence; and an occupation of more honour and profit than was ever drawn from the ſource of robbery: above all, it cannot be leſs honourable to work for the king than for his ſubjects, and I am perſuaded that patriotic attachments and zeal for the public intereſt would ſtimulate a ſoldier to much national ſaving.

The ordinary ways and means of conſtructing canals, are too generally underſtood to need my feeble explanation; I only lament that ſo little attention is paid to the expanſive capacity of finance, and that mankind are ſo exceedingly tenacious of the treaſure in the napkin. It might be greatly accumulated by good and faithful ſtewards of the Lord's intereſt! but it is not my province to criticiſe the non-feaſance of ſocial duties.

There ſeems to be one general point in which all the reſpectable writers on ways and means to increaſe the public revenue ſeem to agree—The public demands ſhould contemplate the leaſt poſſible inconvenience to the pockets of individuals; but, whereever it becomes neceſſary that theſe ſhould be touched, let the reciprocity be made as

viſible as poſſible; for it may be obſerved that right demands taxation, but prudence ſends conciliation in the company of right. Mr. Middleton and Doctor Anderſon prefer the turnpike ſyſtem: it carries fairneſs on the face of it, becauſe mankind ſee the benefits they are paying for. Others prefer mortgaging the premiſes for the means of execution, until the tolls ſhall redeem the expences and ſet the people free. Both, I apprehend, attain the ſame end in reſpect to the ultimate reſult: the one ſtrengthens the national reſources by its voluntary encouragements to a national induſtry which accumulates public wealth and ſtrength for a latteral reſponſibility; and the other demands remuneration for a viſible accommodation.

The only difficulty lies in the preſent ſtate of public neceſſity; Government wants money to enable her protection to ſociety, and the queſtion is, how the ſaddle will gall the leaſt. I have ſuggeſted the principles of foreign and domeſtic popular confidence which occurred to me in my preliminary obſervations; and if I were a rich man, reſiding even in Paris, or in any other foreign land, I ſhould have no heſitation in ſpecu-

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lating upon ſo ſafe a ſubject. We are not, however, without numerous precedents for the model of government loans upon the credit of their future proſpects; and, if I were ſo fortunate as to be a money-lender, I would certainly ſolicit this ſecurity in preference to any beyond the channel. I ſhall only offer one reſource more, which attaches to the condition of human depravity.

Hints towards employing the vagrant and diſorderly Claſſes of the Community in Works of National Irrigation, Inland Navigation, and Drainage; as a remuneration to Society for the Depredations they may have committed.

I ſuggeſt the following ideas, with hopes that they may call the attention of authority to the uſe which they may be of in the police of the metropolis more particularly, in regard to a compulſive application of the time of vagrants and petit criminals to a new ſpecies of induſtry in the item of irrigation; while means may be thereby obtained for the voluntary employment of the induſtrious poor in co-operative occupations.

I apprehend no man can have paſſed the ſtreets of London without being more or leſs incommoded by impertinent importunities from ſome deſcription or other of that diſorderly multitude denominated beggars; and I am perſuaded it would require nice judgment to penetrate the various deceptions that aſſimilate the impoſtor to the real object of charity, if the benevolent founders of numerous public inſtitutions had not ſo greatly removed the propriety of giving alms to ſo promiſcuous a deſcription of people.

Let us inquire then for a moment, whether that benevolent ſpirit of the Engliſh nation, which has been the boaſt of ages paſt, has produced a good or evil in this reſpect? Or, whether by the lure of miſtaken gratuities to innate ſloth, we do not bring about the very ends we incline to prevent; and, whether we do not thus induce many profeſſional impoſitions which it ſhould be our ſtudy to avert by providing means of ſubſiſtence for the worthy indigent, and compulſion for the uſeleſs or villainous.

That we may be better enabled to keep in view ſuch perſons as this kind of inquiry ſhould contemplate, we cannot refer to a better guide than that which has influenced

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legiſlative deciſions through ſucceſſive ages, and afforded ſcope for the notice of that learned judge, Sir William Blackſtone, in his excellent Commentaries, under the head of *Offences againſt Public Economy*, vol. iv. p. 165, to 169.

Such a hiſtory of the riſe and progreſs of nuiſances and petty crimes againſt public economy, as that which the judge has been at the pains to trace from early dates, will not only be found ſomewhat inſtructive to many who are little in the habit of legal inquiries, but it may afford a ſcope of reflection to the curious mind, which will amply repay the trouble of referring to the ſubject; and it will in ſome meaſure prepare us for a more ready diſtinction of the ſeveral objects which the claſſification of misfeaſance ſeems to have fitted for the preſent occaſion.

When we paſs from the ſeveral periods which this very able judge has enumerated in ſumming up the reſpective legiſlative amendments which have been ſucceſſively interpoſed in this behalf, we might naturally have expected to find the condition of man very much ameliorated by this time, through the far-reſounding benefits of civilization! Whether this is, or is not the fact, advocates for

for the more refined ſciences will pleaſe to determine, while I content myſelf with a more humble ſphere, in contriving ways and means to reduce ſuch accumulated evils as a late reſpectable author has exhibited, by rough though ſubſtantial mechanical powers; for theſe would ſeem beſt calculated to bring the worthleſs part of Society to a ſenſe of its duties to the aggregate whole, and, to eradicate the inconveniencies now inquired into with their many-coloured variety of concomitant miſchiefs.

The author to whom I here allude, Mr. Colquhoun, in his ineſtimable treatiſe concerning the police of the metropolis of England, (1796–1797), while enumerating the various crimes and miſdemeanors with which London is infeſted, eſtimates 170,000,000 pounds worth of property to be ſubject to daily depredations; and, after an herculean labour in collecting facts for which his judgment and aſſiduity ſeem to have been peculiarly adapted, he enumerates the detail of this cohort of very formidable depredators in the following eſtimated ſchedule.

Eſtimate

* *Eſtimate of Perſons who are ſuppoſed to ſupport themſelves in and near the Metropolis, by Purſuits either criminal, illegal, or immoral.*

Profeſſed thieves, burglars, highway robbers, pickpockets, and river pirates, who are completely corrupted; many of whom have finiſhed their education in the hulks, and ſome at Botany Bay N. B. There will be a conſiderable increaſe of this claſs on the return of peace, now eſtimated at about —— ——	2,000
Profeſſed and known receivers of ſtolen goods, of whom eight or ten are opulent — —	60
Coiners, colourers, dealers, venders, buyers, and utterers of baſe money, including counterfeit, foreign, and Eaſt-India coin —	3,000

* Treatiſe on the Police, Introductory Addreſs, p. vii.

Thieves,

Thieves, pilferers, and embezzlers, who live partly by depredation, and partly by their own occasional labour — —	8,000
River pilferers, viz. fraudulent lumpers, scuffle-hunters, mudlarks, lightermen, riggers, artificers, and labourers in the docks and arsenals	2,500
Itinerant jews, wandering from street to street, holding out temptations to pilfer and steal, and jew boys crying *bad shillings*, who purchase articles stolen by servants, stable boys, &c. &c. generally paying in base money —	2,000
Receivers of stolen goods from petty pilferers at old iron shops, store shops, rag and thrumb shops, and shops for second-hand apparel, including some fraudulent hostlers, small butchers, and pawnbrokers	4,000
A class of suspicious characters, who live partly by pilfering and passing base money; ostensibly costard-mongers, ass-drivers, dustmen, chimney-sweepers, rabbit-sellers, fish and fruit-sellers, flash coachmen, bear-baiters, dog-keepers (but in fact dog-stealers) &c. &c.	1,000

Perſons in character of menial ſervants, journeymen, warehouſe-porters, and under clerks, who are entruſted with property, and defraud their employers in a little way, under circumſtances where they generally elude detection, eſtimated at about — — 3,500

A claſs of ſwindlers, cheats, and low gamblers, compoſed of idle and diſſolute characters, who have abandoned every honeſt purſuit, and who live chiefly by fraudulent tranſactions in the lottery; as morocco men, ruffians, bludgeon men clerks and aſſiſtants during the ſeaſon, who at other times aſſume the trade of duffers, hawkers and pedlars, horſe-dealers, gamblers with E O tables at fairs, utterers of baſe money, horſe-ſtealers, &c. &c. - - - 7,440

Various other claſſes of cheats, not included in the above, (but deſcribed in pages 148 to 158, vide pages 148, 421, Tr. Pol.) 1,000

Fraudulent and diſſolute publicans who are connected with cri-

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minal people, and who, to accommodate their companions in iniquity, allow their houſes to be rendezvous for thieves, ſwindlers, and dealers in baſe money — 1,000

A claſs of inferior officers belonging to the cuſtoms and exciſe, including what are called ſupernumeraries and glutmen; many of whom connive at pillage, as well as frauds committed on the revenue, and ſhare in the plunder to a very conſiderable extent: principally from their inability to ſupport themſelves on the pittance allowed them in the name of ſalary: eſtimated at — — — 1,000

A numerous claſs of perſons who keep chandler ſhops for ſale of proviſion, tea, and other neceſſaries to the poor: the total number is eſtimated at ten thouſand in the metropolis; a certain proportion of whom, as well as ſmall butchers and others, are known to cheat their cuſtomers, eſpecially thoſe to whom they give a little credit by falſe weights, for which (except-

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ing in the parifh of Mary-le-bone) there is no proper check – 3,500

Servants, male and female, porters, hoftlers, ftable boys, and poftboys, &c. out of place, principally from ill behaviour and lofs of character, whofe means of living muft excite fufpicion at all times, about – – – 10,000

Perfons called black legs, and others profelyted to the paffion of gaming, or purfuing it as a trade, who are in the conftant habit of frequenting houfes opened for the exprefs purpofe of play, of which there are at leaft forty in Weftminfter, where pharo banks are kept; or where hazard, rouge et noir, &c. are introduced. Of thefe, five are kept in the houfes of ladies of fafhion, who are faid to receive 50l. for each rout, befides one eighth of the profits; feven are fubfcription houfes; five have cuftomers particularly attached to them; and thirteen admit foreigners and every idle and diffolute characters, who

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are either introduced or known to belong to the fraternity of gamblers; where a ſupper and wines are always provided by the proprietors of the houſe for the entertainment of their cuſtomers – 2,000

Spendthrifts, rakes, giddy young men, inexperienced, and in the purſuit of criminal pleaſures, profligate, looſe, diſſolute characters, vitiated themſelves, and in the daily practice of ſeducing others to intemperance, lewdneſs, debauchery, gambling, and exceſs; eſtimated at – – – – 3,000

Foreigners who live chiefly by gambling – – – 500

Bawds who keep houſes of ill fame, brothels, lodging houſes for proſtitutes, &c. – – – 2,000

Unfortunate females of all deſcriptions, who ſupport themſelves chiefly or wholly by proſtitution 50,000

Strangers out of work, who have wandered up to London in ſearch of employment, and without recommendation, generally in con-

ſequence

ſequence of ſome miſdemeanour committed in the country; at all times above – – –	1,000
Strolling minſtrels, ballad ſingers, ſhowmen, trumpeters, and gypſies – – – –	1,500
Grubbers, gin-drinking diſſolute women, and deſtitute boys and girls, wandering and prowling about in the ſtreets and bye places after chips, nails, old metals, broken glaſs, paper, twine, &c. &c. who are conſtantly on the watch to pilfer when an opportunity offers – – –	2,000
Common beggars and vagrants aſking alms, ſuppoſing one to every two ſtreets – – –	3,000
Total	115,000

Whether, in reviewing this horrid catalogue of offences and miſdemeanours, we ſhould attribute their increaſe to antient ſeverities not yet expunged from the law, which men are loth to execute on their fellow creatures, (though indeed we now find

many

many ſpecies of crimes that were unknown to former ages, and appear, in a great degree, to owe their accumulation to the rapid progreſs of opulence and the arts) it is not for my preſent purpoſe or convenience to inquire into. It would, in any event, ſeem rational to conclude, in relation to villainy, that that is the beſt mode of puniſhment that can be adapted to the nature of ſocial compact, which contributes to remedy its defects, and to attain its wiſeſt ends at the leaſt poſſible expence, with the leaſt (but effective) degree of cruelty, in a way to compel ſome degree of reſtitution from him who has injured the community by malfeaſance; and ſo that the aggreſſing individual may rather be reſtored to ſome uſeful function in ſocial intercourſe when he is corrected, than to be rendered an outcaſt under a ſtigmatized and irrevocable doom; or be cut off, perhaps, in the prime of life, under that ſocial right of inanimating which the law aſſumes; but which I confeſs myſelf unwilling to aſſent to, on the mere precedent of earlier days, if it were poſſible to diſcover a more lenient ſubſtitute.

I ſhall therefore barely ſuggeſt a workhouſe amendment to the conſideration of thoſe

those in power, by means of an inclosed wheel of about thirty feet diameter, for calculation sake, leaving the actual construction, in point of size and application, to the opinions of those who may happen to be more nearly concerned; for such a kind of walking wheel requires merely the leverage of corporeal gravity put in a state of motion to employ it; and therefore places all men upon a footing of fair equality in gaining a subsistence proportioned to their bulk and appetite; being perfectly independent of tuition, mystery, art, trade, or any particular profession or habit.

With respect to the mode of erecting one of these wheels, I would recommend that it be inclosed in a room so nearly approaching to its own width, that, when the doors of the wheel were open, a complete passage should be formed through it from one room to the other, on each side of the wheel room. By this means, no other road being left open, the labourers should be made to pass through a proportionate work of the wheel in going to their meals and to their bed rooms. Their diet should be wholesome, and plentifully laid in; and always served on a plain decent

table in the room oppofite to that from whence they were to depart. Compulfive meafures, other than the cravings of natural appetite, would be thus fpared, or greatly diminifhed at leaft. The doors of comuni-cation through the wheel fhould be fhut with fpring bolts and pullies for the manage-ment of them, fo that the fuperintendants or directors might manage them without rifque.

In a fimilar way, I think, the more ho-nourable contrivance of open wheels might be conftructed in various places, in order to aid poor induftrious perfons out of employ-ment with a certain means of fubfiftence. In thefe, infolvent debtors, prifoners of war, and other children of diftrefs, might obtain a little help towards a comfortable fubfift-ence, as fome little alleviation of their re-fpective miferies.

For example, then, if we calculate the application of animal gravity, in this way, to mechanic powers for pumping water by a common forcing pump, to fupply a refervoir elevated ninety feet above the ordinary fur-face, for feeding the ducts or water pipes of a town fupplying canals, &c. we may fay as follows: let the dimenfions of the great wheel

wheel proposed be called thirty feet diameter. We will make choice of a pump of four inches bore, having its piston worked by a crank of nine inches sweep, admitting a stroke of eighteen inches to every movement of the piston, which is once up and down for every revolution of the crank axis.

Designing to calculate in round numbers, always throwing away fractions against our allowance of power, that we may be still more certain than otherwise against casual resistance, we are to consider that a column of water equal to eighteen inches stroke and four inches diameter, contains two hundred and twenty-six cubic inches, and eighteen fractional parts.

A column of water of this size, raised to the height of ninety feet above the surface, contains 12063 cubic inches, and weighs 7865 ounces avoirdupoize weight, or 491lb. $9\frac{1}{10}$oz.

If we were to suppose each man walking in the wheel to average 150lb. avoirdupoize, and allow him the full advantage of fifteen feet leverage, (that being half the diameter of the proposed wheel, and so far from the centre of gravity), he would produce a power at the end of the horizontal lever of 1680lb.

after deducting an allowance of $\frac{1}{5}$ for resistance. But as by this mode of applying levers, &c. to rotary motion, a man walking in such a wheel cannot be supposed to make good his weight above the medium angle of forty-five degrees, we must be contented to allow him the leverage of a horizontal beam as far as the intersection of a perpendicular line drawn from the point marked by the given angle, on the circle, would intersect on the horizontal beam, which is near and about eleven feet leverage, producing a nett power of 1320 lb.

I will now allow each man employed to work two of these pumps of four inches bore. At this rate the resistance in the two columns of water, each 90 feet high, will be 938 lb. with some little friction on the works besides; and the power to be applied or opposed to this resistance will be 1320 lb. which leaves 327 lb. spare power to overcome the resistance with, and may, I presume, be considered very light labour.

Now the pistons being moved up and down in the pump, by means of the crank, as it is turned round by the trundle or spur-wheel, raises and depresses the two pump-rods, and there are two successive strokes of eighteen

eighteen inches each made by these two piſtons for each revolution of the crank, ſpur, or trundle-wheel. And if the wheel which works in the ſpur or trundle has three times as many coggs as the ſpur or trundle has ſpurs, ſtaves, or rounds, the ſpur or trundle and crank will make three revolutions for each time which the great wheel moves round; and as each crank, reſpectively employed, will perform its ſtroke, there will be ſix ſtrokes diſcharging each a column of water eighteen inches high, and four inches diameter; containing each 226 cubic inches for each and every revolution which is performed by the great walking wheel.

Every poſſible care ſhould be taken to avoid friction, by conſtructing the machinery ſo as to move the piſton-rods perpendicularly. Various methods have long been tried for improving this purpoſe; ſuch, for inſtance, as vibrating-levers, jointed crank-rods, friction-rollers of ſeveral kinds, &c. But I think none approach ſo near rectilineal perfection as the new method uſed by Mr. Foulds, at the London Bridge water works, and that by Mr. Cartwright, applied in the patented ſteam engine*.

* See Philoſophical Magazine for July 1798, p. 1.

The circumference of the great walking wheel is 90 feet, or 30 yards; and the yards in a mile are 1760: which ſum, divided by 30, gives $58\frac{2}{3}$ turns in a mile.

If then we regulate the velocity of the great wheel to only two miles an hour, (which cannot, I think, be conſidered as very hard walking, after lazineſs ſhall have acquired the habit through inducement or coercion), there will be $117\frac{1}{3}$ turns of the great wheel in an hour which wants but $2\frac{2}{3}$ turns of 120, and is near enough to be conſidered accurate at two turns in a minute, or one revolution of the great wheel for every half minute of time.

Hence we find that ſix ſtrokes are performed in each half minute of time by a wheel conſtructed for one perſon; making 720 ſtrokes per hour. This, when fractions are thrown away againſt caſual waſtage, being multiplied by the round number 226, which are the quantity of cubic inches forced into the main-pipe and diſcharged by each ſtroke of the piſton, produces 162,720 cubic inches per hour; which ſum being divided by 231, (which are the cubic inches contained in a gallon, wine meaſure), raiſes $704\frac{1}{2}$ gallons per hour. This ſum, divided again

again by 63, gives above 11 hogſheads of water per hour for each man's weight, beſides 11 gallons and ſome fractions over; which, though nothing in compariſon with Meſſrs. Dixie and Mapleſtone's machine, is ſufficient for our purpoſe in the preſent computation.

If thus we only appropriate 9 hours in the day to labour, (which is but a walk of 18 miles per day: probably far leſs than that to which vagrant habits are accuſtomed), it ſupplies (with the aid of a few fractions), 100 hogſheads per man; and this product multiplied by 6, which is the number of perſons which, for farther eſtimates ſake, I ſuppoſe a wheel to contain at a medium rate, it would give 600 hogſheads per day; which may reaſonably enough be conſidered as a ſufficient ſupply for an equal number of moderate ſized families, obtained by the labour of ſix otherwiſe uſeleſs (perhaps criminal) beings, who have been heretofore wont to prey upon the induſtrious part of the community.

But if we either ſuppoſe the perſons who occupy ſuch a wheel to be men ſo far above the middle ſize as to weigh 200 lb. which is, I ſuppoſe, about the average weight of your

your firſt rate beef-eaters; or, if you make up an equivalent to ſuch a weight by the addition of ſupernumerary ſmall men, your power will then be 1788 lb. leverage per man, equal to the full leverage of the ſemidiameter in the former caſe, and may be ſuppoſed to work one third more pumps with eaſe; which will be at the rate of 900 hogſheads per day, to a reſervoir elevated 90 feet above the ſurface of your lower level.

Eſtimating all conditions of perſons, then it certainly will not be deemed a ſeverity if we ſay, that when any man having the uſe of his legs can ſupply 100, and ſome men 150 houſes per day with water, through the mere application of their reſpective weights as a mechanical power, when applied to machinery; and this means of getting bread is once provided for them, (making a proper diſtinction between thoſe who work voluntarily, and thoſe who are under the * conſtraint of the law), there can be no need to encourage

* It will be obſerved, that when ſix men are thus incloſed in a wheel, there will be no occaſion for corporeal puniſhments; for the equilibrium being deſtroyed by the movement of one man's foot inſide, or by the overſeer's hand outſide, the obſtinate will have their choice

encourage begging in the ſtreets by a miſtaken charity, which has, I apprehend, a more frequent tendency to incommode the heart of indigent ſenſibility than to ſuccour real diſtreſs.

We have ſeen in Mr. Colquhoun's eſtimate of indolence and villainy, that the perſons in and about London alone who are ſuppoſed to ſupport themſelves by purſuits either criminal, illegal, or immoral, amount to no leſs a number than one hundred and fifteen thouſand!!!

Is it not then worthy of conſideration, whether the great and opulent City of London may not legally and conſtitutionally find thoſe who have ſo long wantoned with her inadvertency ſome conſtant employment of this nature, whereby the condition of the community may be bettered; thieves and vagabonds may be compelled to make ſome degree of recompence for their depredations on ſociety; and ſloth may be awakened to the habit of providing food and raiment

choice to move forward or fall upon their noſes; and the cravings of the ſtomach will be an inducement to "keep moving," when a breakfaſt or dinner is a thing certain at the end of a given diſtance.

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through a more equitable medium than that of taxing the induſtry of others.

The ſyſtem of national irrigation which I propoſe, or, in other words, the ſcience of inland navigation, watering, and drainage, affords an abundant field for ſuch improvement; nor do I ſuppoſe there is a city in the univerſe, of comparative commerce and locomotion, where a defective attention to theſe moſt productive of all reſources and moſt intereſting of all facilities is ſo truly conſpicuous to the eyes of thoſe who are accuſtomed to think on theſe important ſubjects, and who calculate the means of accumulating public wealth, and of alleviating the miſerable condition of animal labour.

If we eſtimate upon the large ſcale for ſupplying the water of a canal elevated 90 feet above the ordinary ſources of the ſtreams, thus enabling ourſelves to extend ſmall branch canals into every part of the country, in a way to prove them aſſiſtants rather than oppoſers of the canals which are already conſtructed, we ſhall find that the moderate labour of theſe 115,000 middle ſized perſons (if it could either be compelled or induced), would feed no leſs than 341 miles of ſmall canals per day; or the greater quantity

tity of 511 miles if large men were employed: for, if we ſuppoſe three feet deep throughout, and a proportionate width to be ſufficient for this kind of conveyance, calculated to extend into and fertilize the remoteſt corners of the iſland, there will be about three cubic yards of water required for each lineal yard of canal; which is five thouſand two hundred and eighty yards to each mile. And if 115,000 idlers, of the ſmaller weight, are ſuppoſed to work two pumps to each man they will ſupply 1,804,882 cubic yards, or 341 miles, in nine hours. But if the greater ſized men are employed in the ſame wheel, they will be able to work three pumps to each man; and conſequently add fifty per cent. which is 511 miles of ſmall canal water per day: a ſupply, which after once being full, would probably reinſtate the abſorption and exhalation of the largeſt canal in the kingdom, to the whole extent of that diſtance.

Much more than this might be performed with the rotary pumps of Medhurſt, Dixie, and Mapleſtone, &c. in their preſent improved ſtate, of which I may in future have occaſion to ſay more; and there are many other methods far preferable to my example.

The

The ſpecimens I have given in the caſe of water to be raiſed by the common pump, may ſufficiently demonſtrate the capacity of this ſpare power of the nation for many other works in various parts of the kingdom. But it reſts with the wiſdom of the Legiſlature to draw ſuch inferences from this ſketch, as they may think intereſting to their conſtituents.

A Plan for raiſing the Supply of Water, which is delivered from the Mains to the ſeveral Houſes in Bedford Square for their Uſe in houſehold and culinary Purpoſes, up to the Roofs of the ſaid Houſes; for retaining the ſaid Water in Ciſterns, formed in the reſpective Roofs, ſo as to be ready at Hand in caſe of Fire; and for delivering fifty Gallons thereof per Day per Houſe, in a pure tranſparent State, obtained by the Uſe of a filtrating Medium, reſembling that by which Nature Acts in the cleareſt Emiſſion of her Springs.

It is preſumed that it will be needleſs to introduce this ſubject by an elaborate notice of

of the great advantages which arife from an eafy command of water for culinary and houfehold occafions; nor will it be neceffary, in this place, to eftimate the cheapeft means. It will be fufficient if it is demonftrated by an approximate eftimate, grounded on the actual prices which may be now engaged in contract, that it is a matter of comparatively cheap purchafe to attain a command of water ready to extinguifh fire, to wafh and fcour the houfe without the labour of carriage up ftairs, to promote an univerfal cleanlinefs, and to fecure health and comfort in a greater degree than can be expected from the ordinary ufe of water charged with impurities and animalcula, and producing the dire effects of gravel and ftone on the human conftitution.

Bedford Square is underftood to contain fifty-two houfes, whofe fronts occupy an average of thirty feet each, depths an average of fifty feet each, and heights about feventy-five feet.

There are five ftreets that enter this fquare, *viz.*

1. Gower-ftreet.

2. A new ftreet leading to the Duke of Bedford's grounds.

3. Charlotte-ſtreet.

4. Caroline-ſtreet.

5. Bedford-ſtreet.

If we allow theſe ſtreets to occupy an average of 70 feet each, they will extend in all 350 feet on the ſide lines of the ſquare; and if we add to this ſum 52 houſes of 30 feet each, reaching 1560 feet more along the ſide lines of the ſquare, it will make the whole circumference of the ſquare amount to 1910 feet, or 477½ feet diameter, or per ſide.

Now having ſtated theſe dimenſions, it follows to premiſe that two methods are preſented, whereby with the help of machinery, to be moved by wind, by ſteam, or by animal power, it is poſſible to diſtribute water from an ornamental building erected in the centre of the ſquare, into the tops or roofs of every houſe at a very moderate expence; more eſpecially when the combination of power and ſyſtem are applied to the operation.

Theſe methods are:

1. By means of an elevated tower, and chain, or forcing pumps.

2. By means of a receiver and diſtributor, aſſiſted by an air veſſel.

The

The first of these might be constructed in the form of a naval column similar to the monument near London Bridge, a tower, an obelisk, or a pagoda, whose height must be at least equal to that of the houses in the square; and the building required for the moving powers might either form a part of the pile or be sunk below the level line of the grass plat, so as to impede no obstacle in the prospect.

The second method (being independent of height), might be confined within the space and form of a proportionate sized temple of pleasure; and it would be easy to mold the air-vessel of the distributor in the shape of a handsome and useful statue, far better than a statue merely ornamental. In this case the horses required to fill the main pipes, would work wholly out of sight in a building beneath the level of the surface, and encircled by an iron rail, adding beauty to the temple within it, which might be accommodated with seats.

I will endeavour to make an approximate computation of the expence according to each of the several methods; but previously it is to be observed, that by the first proposed method, the easy labour of two horses

and a boy for one quarter of an hour each and every morning will be found fully competent to ſupply each houſe with one hundred gallons of water, elevated into its ſummit reſervoir; from whence the diſtribution is both ſimple and at option, according to fancy and the diſtributive arrangement of the pipes which communicate to the ſeveral apartments below the reſervoirs.

Agreable to the method which embraces the ſimple fountain principle, the water muſt be firſt elevated into the reſervoir of the tower or pagoda, and from thence, by means of communicating pipes, it may be made to find its own level on the top of any and every houſe in the ſquare; and it may be communicated along the roofs of the houſes to the ſummit ciſterns of each reſpectively, either in an open channel, or in a cloſe leaden pipe with proper air-tubes, &c. In this point, indeed, the ciſterns may be ſo conſtructed as to be capable of diſcharging their whole contents of water ſuddenly into the flames of any houſe which might happen to take fire.

There can be no invariable rule adopted for calculating the coſt of the pipes below; becauſe this muſt depend on the pleaſure of the

the party, in regard to the diſtributive arrangements which are preferred in the economy of the ſeveral families. And the leſſening of expence will partly depend alſo on the ſpirit of unanimity and accommodation which prevails throughout the neighbourhood; for if any one or more of the proprietors chooſe to decline their quota of the expence in the general work, it can be no reaſon for any inhoſpitable objections to permitting the pipe to paſs over the roof of ſuch houſe to the accommodation of the next neighbour.

The expence of the central building, in this caſe, is entirely a contingent matter, and depends wholly on the will of the parties concerned, and the degree of ornament they are inclined to beſtow on the ſquare.

The works which come under the more particular notice of a civil engineer are matters of regular calculation, which depend on the nature of the premiſes, the degree of elevation, and the quantity of water to be raiſed in a given time. If we allow each family to conſume one hundred gallons of water per day, on an average, the quantity demanded will be 5,200 gallons per day; the elevation 75 feet; and the length of

 main

main pipe will be equal to five ſemi-diameters of the ſquare, or about 350 yards, if we deduct the width of the areas which ſerve as front yards to the houſes. One-fifth of this pipe being deſigned to let the water into the lower level, baſin, or reſervoir in the centre of the ſquare, from the main pipes of the public water-works, ſhould be equal in diameter to thoſe pipes which I ſuppoſe to be four inches.

If we allow the column of water, which will be thus contained in the aſcending pipe, to have an elevation of 80 feet, (for we ſhould add a few feet for ſafety's ſake) its weight will be about 436lb. avoirdupoiſe; which, together with the friction of the water acting on the pipe and the moving machinery, is the reſiſtance to be overcome by the two horſes, whoſe ſtrength is to be applied to the beam or lever.

On Dixie and Mapleſtone's machine, the reſiſtance againſt the riſing water will be little more than that of the common atmoſphere preſſing againſt the buckets; for theſe, being fixed on an endleſs ſtrap of chain or ropes, which paſſes in conſtant rotatory motion, will always balance each other.

If

If we allow the lever, to which the horſes are fixed, to make good a diameter of 26 feet 8 inches, from centre to centre of the horſe path, the circumference of the leverage will be 80 feet; which is exactly the pitch of the aſcending main or elevation which we have adopted: and, if the buckets moved only at the ſlower rate at which the horſes walk (which buckets I will ſuppoſe to be of equal contents to the four-inch main pipe before ſtated) there would be 436lb. avoirdupoiſe weight of water or thereabouts, which, at 8lb. per gallon, is 54½ gallons, diſcharged into the upper ciſtern for each time which the horſes walk round the circle; making a diſcharge of 3564 gallons of water for one mile walking of the horſes: this, at the rate of two miles per morning, would do more than ſupply each houſe with 100 gallons, and allow amply for waſtage.

But as this would be a method of raiſing water by a very tedious proceſs, compared with what is practicable, let us ſuppoſe the drum, pin, or ſprocket wheel, round which the endleſs ſtrap revolves, to be 2 feet 8 inches diameter, and it will require 10 revolutions of this wheel to one revolution of

 the

the endlefs ftrap which is loaded with buckets. And, if the cog wheel, which is fixed on the perpendicular fhaft into which the lever or beam is framed, has four times the number of cogs which the drum or fprocket wheel has fpurs or rounds, the fame two horfes and boy will be fully competent to fupplying all the houfes in Bedford Square with 100 gallons per day each by light work for one quarter of an hour each day; which labour might be performed, in routine, by the carriage horfes, as a morning's exercife; and would reduce the expence of boy and horfes to a total faving of this item.

The coft in this way would be approximate to the following

Eftimate:

Elm pipes.	£.	s.	d.
350 yards of elm main pipe, 4 inches diameter, at 2s. 6d.	43	15	0
Laying down ditto 350, at 6d. per yard - - -	8	15	0
Joints, &c, at 1 foot per joint, 10 yards, at 2s. 6d. -	1	5	0
Cartage, 350 yards, at 2d.	2	18	4
Carried forward	£.56	13	4

Leaden

Brought forward	£.56	13	4

Leaden pipes.

320 feet 2-inch aſcending pipe, at 7s. per yard – –	37	16	8
1000 feet 1-inch diſtributing ditto, at 3s. per yard –	50	0	0
5500 feet half-inch deſcending ditto, at 2s. per yard	183	6	8
Soldering joints, ſay 10 per houſe, 520, at 2s. –	52	0	0
Balls and cocks, ſay each houſe 5l. – – –	260	0	0
52 ſummit ciſterns, each 6 feet every ſide, being 180 ſquare feet each, in all 9360 feet, at 7lb. per foot, is 585 cwt. at 1l. 10s. per cwt. incluſive – –	877	10	0
1 Reſervoir, 180 ſquare feet, at 7lb. per foot, 11 cwt. 1 qr. at 30s. – –	16	17	6
320 feet 2-inch deſcending pipe, at 7s. per yard –	37	16	8
Carried forward	£.1572	0	10

Brought forward	£.1572	0	10
Millwright's work.			
Horſe mill for 2 horſes complete, 30 feet in diameter, at 4l. per foot per cuſtom	120	0	0
Dixie and Mapleſtone's machine.			
Buckets and chain complete, 80 feet perpend. at 10s.	40	0	0
Extra work and fixing -	10	0	0
	1742	0	10
Allow for wooden work, tower, &c. - -	257	19	2
	£.2000	0	0
Drawings, labour, and contingencies, 20 per cent.	400	0	0
Four filtering machines, each 25l. - - -	100	0	0
	£.2500	0	0
Engineer and ſuperintendants, 5 per cent. - -	250	0	0
Total	£.2750	0	0

It will be here obſerved, that I have allowed a large eſtimate, and have perhaps computed a total expence greatly beyond that which would be ſufficient; and for which a regular artiſt or practical engineer would engage to perform the work. I am aware of this circumſtance, and have only to reply to it, that it ſeems to be often found that engineers engage for a ſum, in theory, which is found very inadequate in practice; and it ſeems therefore better to allow roundly at firſt, and let the proprietor, if he is diſappointed at all, be at leaſt very agreeably diſappointed.

In addition to the advantages which are promiſed, by this ſyſtem, to houſehold and culinary accommodation, there are many inſtances in which ſuch a command of water as is here contemplated may be applied to our gratification in luxurious indulgencies: baths may be thus eaſily and cheaply conſtructed in the cloſets of our bedchambers, and health, ſtrength, and cleanlineſs be thereby greatly promoted. Fiſh ponds may be thus contrived for the accommodation of private families, while the conſtant dripping of water may be made to cool and purify the air by means of evaporation, and a gentle

breeze

breeze may be created in the mid-day heat by the action of a dinner fan, to which the water may give a mechanical motion that can be governed at will.

The grafs plat in the fquare can be eafily irrigated from the fame refource; and, by paffing a pipe round the top rail of the iron inclofure (at an additional expence) the bordering fhrubbery can be regularly watered with little trouble; while the Spanifh method of applying the perforated tube may be alfo adopted to lay the duft of the furrounding pavement. In fhort, there can be no doubt that many ineftimable benefits may be derived from fuch a fyftem: the difficulty, perhaps, is to find a popular mode of adopting meafures of public benefit, which fhall obviate the oppofition of party interefts, and the inertnefs of an enterprize which is left to the office of every body and nobody. If fomebody would but ftep forward and be active, there feems to be no great doubt that the field itfelf may be rendered interefting to all; and that when once the refult is demonftrated by the experience of the fcite which I have chofen, for fake of a central example, this fyftem of houfehold economy, which Bedford Square fhall

have then adopted, will emanate from thence into all the ſquares and ſtreets of the metropolis, and render its influence a common bleſſing, by diffuſing its general ſpirit throughout the ſeveral water-works of this populous city.

Of watering and waſhing Roads.

The following accounts of watering and waſhing roads are publiſhed lately in the Second Volume of Communications to the Board of Agriculture, by Mr. Wright of Chelſea, and Mr. Ellis. Mr. Wright ſays, "The roads that are watered in the neighbourhood of London by truſtees *, do not extend more than three miles, excepting the Brentford truſt, which extends to Smallbury Green, near Hounſlow.

"The watering roads is a complicated buſineſs, ſome being done by an additional toll from Lady-day till Michaelmas; others by an aſſeſſment on the inhabitants. No turnpike truſt waters except it is ſpecially expreſſed in the act of Parliament. The truſtees of Kenſington and Brentford have their roads done by hire; they have pumps fixed, which is attended with conſiderable

* Many roads in the vicinage of London are watered at the expence of the inhabitants.

expence,

expence, and water carts of their own. The horſes and men work by the day; and at the neareſt calculation I can make, it coſts 6s. 6d. per mile, every day they water, for the men and horſes. The truſtees of Iſlington keep teams of their own, which are conſtantly employed in leading gravel or watering the roads; and they find this mode cheaper and more convenient. Thoſe roads that are watered by an aſſeſſment on the inhabitants are moſtly done by contract. I am of opinion, that the mode of watering roads might be improved; the method now followed muſt in ſome degree injure them. The carts are drawn by one horſe, which has not ſtrength ſufficient to pull ſo weighty a machine, laden with water, but is obliged to reſt two or three times before the cart is empty; which cauſes torrents of water to reſt on thoſe parts of the roads, and occaſions the holes and chaſms that may be ſeen in all roads that are watered. The water carts, in my opinion, ſhould be drawn by two horſes to go a regular pace, that the roads might have an equal quantity of water; the trough or cullender at the tail of the cart is too far from the ground, and the conſequence is, the water comes with too much force on the roads,

roads, which is in part the cauſe of thoſe holes before mentioned. I am of opinion that a cullender might be contrived at the bottom of the cart, and nearer the ground, which would water the roads more regularly, and might be ſtopped entirely when neceſſary. I differ in opinion with many reſpecting watering roads, and think it advantageous, provided the roads be kept clean. When roads are moiſtened by a ſhower of rain, or a water cart, the perpetual preſſure of the broad-wheeled waggons muſt bind and firm them; and the narrow-wheeled carriages at that ſeaſon of the year do not remain on the ground a ſufficient time to injure them. If the roads were well cleaned in the ſpring, and the dirt and duſt carted off, a ſmall quantity of water would make them pleaſant, without injuring them; but according to the preſent practice, the duſt or mud is raked in heaps on the ſides of the roads; there it lies to be conſumed and blown about, which annoys both travellers and thoſe who live in the neighbourhood.

The watering of roads is ſo incidental an undertaking, that no judgment can be formed of the expence, but by the mile. If the repairing of roads were farmed, the water-

ing would require but a ſmall expence, compared to what it coſts truſtees. A contractor would have the benefit of all the accidental ſhowers which happen at this ſeaſon, and no time would be loſt, as his men and teams would be ready for any other kind of employ, when not wanted on the roads. Truſtees moſtly pay for the whole day, if the teams only work a few hours. I can only add, that the principal cauſe of ſo much dirt and duſt is occaſioned, not by watering, but by laying on too large a quantity of gravel at an improper ſeaſon of the year, namely, the ſummer, which does not bind, and is ſoon ground down to duſt.

"It might not be improper to have an experiment tried in Hyde Park, where there is abundance of water to be had, and where laying the duſt would contribute ſo much to the health of the individuals of the metropolis. Let proper carts be conſtructed, with a cullender at the bottom of the cart, ſo that the water could not come out with ſuch force, and it might be ſtopped at once, when they turn, or when the watering is not neceſſary. Let there be two horſes inſtead of one, as it is too heavy a load for one horſe when the cart is at all full; and let them

water

water twice a day, at four in the morning, and at eleven, when the weather requires it; and it will ſoon be found, that a ſmall quantity will not injure them; on the contrary, will bind the gravel, if it has been laid on in autumn."

Mr. Ellis has added the following remarks: "Roads upon which traffic is conſiderable, and the materials for mending not of the hardeſt quality, are apt to be extremely duſty in ſummer, and loaded with mud in winter. The uſual method of cleaning them has been by ſcraping; but to this mode there is a material objection, that much gravel is carted away, as it is not eaſy to ſeparate the ſtones which are ground down from thoſe which are only broken. The expence of thus cleaning is alſo conſiderable. Theſe evils occaſion another, that of waſhing away the mud; this has been found cheaper, more effectual, and takes off only the particles ground too ſmall to be uſeful. But it can be applied only in certain ſituations: there muſt be a declivity to prevent the water ſtagnating; it ſhould run freely, but not with too great rapidity. Where brooks and ſtreams cannot be turned in, which is often the caſe, reſervoirs by the ſide

of

of the road anfwer the purpofe, if prepared with attention *."

I beg leave to add to thefe remarks, that if the plan of national irrigation which I have herein fuggefted fhould be adopted, I can fee no reafon why the department for watering turnpike roads fhould not form a branch of the public fyftem; nor do I apprehend that the expence of irrigating the roads by the means of perforated pipes would ultimately refult in other than a faving of public economy.

* The fubjoined note is added to this paper by the Board of Agriculture:

"These hints are prefented, that the Board may fhew their attention has been given to every circumftance concerning the roads of the kingdom, relative to which any communications have been made to them. It would be extremely defirable, to have more complete information on the fubject of watering and wafhing roads, from fome of their intelligent correfpondents, who have paid particular attention to thofe fubjects.

Circular Letter from the Board of Agriculture on the Subject of Irrigation; together with Remarks thereon, extracted from a Letter written to the Board on that Subject by an intelligent Engineer.

Howſoever extraordinary it may appear, that a man ſeeking knowledge on the ſubject of irrigation, and leaving no ſtone unturned which might promiſe to afford it, (as I truſt the numerous authorities cited will teſtify) ſhould have omitted till the laſt that which many would ſuppoſe policy alone would have dictated for the foundation of his work; yet it is certainly not leſs extraordinary than true, that notwithſtanding I have had repeated interviews with Sir John Sinclair himſelf, and ſeveral others of the moſt reſpectable inveſtigators on this topic, and to whoſe liberal references and communications I am very greatly indebted, yet I have never been able to ſtumble on the following papers till my book was completed

 up

up to the page where I now insert them. This will appear possibly still more strange, and may perhaps be ascribed to the modest taciturnity of that indefatigable friend to agriculture, when it is known that he had paid a very early attention to the subject, and that he did not omit to notice it in the third article of the summary conclusion of his papers concerning the origin of the Board of Agriculture, in the following words *:

"Another separate head of inquiry, and source of incredible wealth, is, the riches to be derived from the streams, rivers, canals, and inland navigations, coasts, and fisheries of the kingdom. That many additional millions per annum might be obtained by a proper attention to those unbounded sources of national riches, can hardly be questioned. By extending inland navigation, by improving the harbours on our coasts, and by carrying our fisheries to the height of which they are capable, it is impossible to say what additional treasures might not be accumulated. That, however, must

* Communications to the Board of Agriculture, Vol. I. p. lxxviii.

entirely

entirely depend on our making the neceſſary inquiries, and following up a regular ſyſtem of improvement."

Thinking it neceſſary to call the attention of the community to the advantages of applying waſte water from the canals to the purpoſes of irrigation, he has alſo ſubjoined the following circular letter, with remarks made in anſwer to it by an experienced engineer.

Circular Letter to the Canal Companies.

" I am requeſted by the Board of Agriculture to ſubmit to your conſideration a ſubject of conſiderable national importance, *that of applying navigable canals to the purpoſe of irrigating or watering land.* We have every reaſon to believe, that the canals already formed, or now forming, might be made applicable to this very material uſe, without any injury to their common deſtination; for though it might not be proper in many caſes to ſpare water in ſum-

mer, yet in winter and ſpring, when moſt abundant, and leaſt eſſential to navigation, its utility, if thrown on the adjacent lands, would be indiſputable; and by this means a conſiderable revenue might accrue to the owners of canals, by granting certain quantities of water, weekly or monthly, to the proprietors of the adjacent ground, and infinitely to the advantage of the public.

"Should this idea meet with your approbation, the Board would apply for a general act of Parliament, to permit the proprietors of canals to make this uſe of their waſte water, and for any other general regulations reſpecting canals which may be thought neceſſary, and which you might have the goodneſs to ſuggeſt. The act might paſs ſo early, that it might be in your power, in the courſe of the enſuing winter, to try experiments on the practicability of the meaſure. Engineers, ſkilled both in navigation and irrigation, would ſoon aſcertain what quantity of water could be ſpared from each canal, at the different ſeaſons of the year, and the extent of land over which it might be conveyed. It may not be improper to inform you, that this uſe of navigable canals has

long

long been common, and carried to a conſiderable extent in the Milaneſe, where the rents paid for water thus taken have in ſome caſes equalled the expence of forming the navigation; that this plan has rendered that part of Italy among the moſt fertile and opulent in Europe, and contributed more to the improvement of the country than any other idea that has been adopted. It is from the water meadows thus obtained that the celebrated Parmeſan cheeſe is in many inſtances produced.

"The anxiety felt by the Board of Agriculture for extending the benefits reſulting from your uſeful undertakings to new objects, which might prove equally beneficial to yourſelves and to the public, has occaſioned this trouble on the part of,

"GENTLEMEN, &c."

Extract of a Letter from an intelligent Engineer on the foregoing Subject.

"I have received your circular letter reſpecting the plan of watering of land by the means of navigable canals; on which there ought only to be one opinion as to its being a point of the greateſt importance, which could have come under the conſideration or patronage of the Board of Agriculture; and if any obſtacles ſhould occur, they muſt ariſe from prejudices which time will wear off; for that ſuch a rational application of the waſte water of canals will at one period or another take place, ſeems not to admit of a doubt.

"In Europe, the improvements of the Milaneſe are a ſtriking inſtance of the fertility which may be created by ſuch an application of the waſte water of canals; and if any thing elſe was wanting to add to this conviction, the economy of the waters of the Nile may be produced as another inſtance, and perhaps even a more ſtriking one than the Milaneſe; as in this laſt

laſt caſe, an unrivalled fertility was ſpread over the ſandy waſtes of Egypt and the Thebais, and even over the ſcorching plains of Lybia.

"The lake Mœris, formed as a reſervoir in the boſom of barren mountains, is a feature which cannot be miſtaken; and it ought to prove a uſeful leſſon for the management of rivers in general, moſt of which, in ſome place or other, may be treated in the ſame way: the exceſs of floods may be drawn off, and in dry ſeaſons water may be iſſued for the uſe of navigations of the ſame rivers, for the working of mills, for the purpoſes of watering land, and for ſupplying navigable canals.

"The very lakes which now exiſt in Great Britain may in general, and at a very moderate expence, be raiſed a few feet above, or drawn off a few feet below, their uſual level; and this, upon extenſive ſurfaces, would ſupply a quantity of water which would produce much fertility to the countries which lie below that level.

A general ſurvey of the kingdom, directed ſo as to aſcertain the comparative levels of its ſurface, would be a very neceſſary ſtep towards

towards the general management of water; and this furvey fhould be made with great accuracy, and noting the leading objects and peculiar advantages and difadvantages in each diftrict, with their relative fituations as to the connecting diftricts; and from thefe feparate reports and furveys a general arrangement of the whole might take place, and many ufeful plans be pointed out.

"In general, I fhould fufpect that in this bufinefs there are evils to be guarded againft, and which are likely to arife from two very oppofite claffes of people. In the one clafs may perhaps be ranged thofe land-owners and mill-owners, whofe minds are not fufficiently enlightened as to be fenfible of the general utility of the fcheme, or the benefits which muft eventually arife to themfelves; and they, of courfe, will be averfe to fubmitting to any alterations which may interfere with the water.

"And the other clafs will confift of projectors and projecting engineers, who may be in any fhape engaged in the arranging or executing this plan, and who being wholly engroffed with new fchemes, may be led to depife real obftacles, and give a favourable complexion to impracticable projects.

As

As the firſt, it is hoped, will not form a majority of the community, an act of Parliament will remove all legal obſtructions as far as it reſpects them; and a perſeverance in repeating calm demonſtrations, and the ſenſible operation of the ſcheme itſelf, muſt in the end convince them, that ſo far from this plan proving an injury or injuſtice, that not only the country at large demands it, but that they will be benefited individually; indeed, there is no reaſon but their own obſtinacy, why they ſhould not be benefited immediately, and that in a double capacity; becauſe, as canal ſtock is transferable and fluctuating, theſe land-owners and mill-owners may become proprietors of the canal navigations, and ſo receive a ſhare of the advantages ariſing from this diſtribution of water, and they may likewiſe, in this way, have a voice in the direction of its operations.

"And beſides this, canal ſtock ſeems more than auy other property to connect the apparent intereſts of the greateſt number of individuals, with the improvement of the land and manufactures of the counties through which the canals paſs, ſince it is in proportion to this proſperity that the canal proprietors can receive their pecuniary ad-

vantages from an increaſed tonnage; thus a number of perſons reſiding in diſtant quarters of the kingdom, who probably could never have become land-owners, are in this way intimately connected with the improvement of the land, &c. This is the circumſtance that I take the liberty of mentioning more at length, becauſe I do not recollect that it has hitherto been taken notice of; and it appears to me of conſiderable importance. I have for inſtance obſerved, that in a certain inland canal navigation, where there are upwards of 1200 proprietors, moſt of them people in tolerable circumſtances, and in trade, and reſiding in twelve counties; that all of them are looking with anxiety to the increaſing produce and conſumption of Cheſhire, Derbyſhire, Montgomeryſhire, and Shropſhire, although, if it had not been for this circumſtance, very few of them would have known or have concerned themſelves about that part of the country.

"With regard to the being led aſtray by projectors, or projecting engineers, this may be in a great meaſure prevented by the choice in the appointment of the engineers who are to take the ſurveys, and the Committee under which they ſhall act, and the care to

be

be taken in the comparing and arranging the ſeveral reports and ſurveys, and many of the Members of the Board of Agriculture will, from their own local knowledge, be enabled to check any falſe repreſentation."

Before I diſmiſs this ſubject, I feel it a duty which I owe to inventive talent, and to the unpatronized engineer, of ſelf-taught abilities, to take ſome notice of a hackneyed habit which many profeſſional men have adopted in reſpect to the proſperity of Genius; who they affect rather to conſider and treat as the enemy of the arts, than the parent of human improvement, and of all the old beaten-track knowledge which tuition and time has been able to beat into that invariable ſyſtem, the ultimatum of their capacity. One would ſuppoſe, alſo, from the extreme care which ſome are wont to take in their cautions concerning the public intereſts (permit me to ſay a little out of their path in trade) that they either conſidered the Board of Agriculture and Parliament as a parcel of political ſchoolboys ſent to London for their inſtruction; or that they were diſtruſtful of their own ſtrength: had forgot that projection is the ſcience which alone can complete a maſterſhip in their moſt ho-

nourable profession, and give them bread; or perhaps their good luck in being heretofore employed by men who were either too proud, too weak, or too dissipated to look into their own affairs, had induced them to view the Board of Agriculture as cattle of this description. I can only say, that on a review of the premises, (let what will have been the motive) common reason would seem to revolt at its dictatorial impudence, and its grovelling illiberality. The mighty work which established this grand national institution, (from which all the world have derived extraordinary light and benefit) has nothing selfish: yet Sir John Sinclair, whose unparalleled zeal will record him among the benefactors of man, to the latest period of time was a *Projector*.

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Printed by M. A. LOW, Berwick Street, Soho.

A

PRACTICAL TREATISE

ON DRAINING

BOGS AND SWAMPY GROUNDS, &c.

A
PRACTICAL TREATISE

ON DRAINING

BOGS AND SWAMPY GROUNDS,

ILLUSTRATED BY

FIGURES;

WITH

CURSORY REMARKS UPON THE ORIGINALITY OF MR. ELKINGTON'S MODE OF DRAINING.

TO WHICH ARE ADDED,

Directions for making a New Kind of Strong, Cheap, and Durable Fence, for Rich Lands; for Erecting, at little Expence, Mill-Dams or Weirs upon Rivers, that ſhall be alike Firm and Durable; for effectually Guarding againſt Encroachments by the Sea upon the Land, and for gradually raiſing Drowned Fens into Sound Graſs-Lands.

AS ALSO,

DISQUISITIONS CONCERNING THE DIFFERENT BREEDS OF SHEEP, AND OTHER DOMESTIC ANIMALS;

BEING

The principal Additions that have been made to the Fourth Edition of ESSAYS relating to AGRICULTURE and RURAL AFFAIRS; publiſhed ſeparately, for the Accommodation of the Purchaſers of the former Editions of this Work.

BY

JAMES ANDERSON, LL.D. F.R.SS. &c. &c.

MEO SUM PAUPER IN ÆRE.

LONDON:

PRINTED FOR G. G. AND J. ROBINSON, PATERNOSTER-ROW.

1797.

ADVERTISEMENT.

The Author returns his best acknowledgements to those gentlemen who have obligingly offered to come forward with attestations of the success they have had, in following the directions given in former editions of this Work; but hopes, they will permit him to decline their obliging offer on the present occasion. He has no anxiety on this head; and is perfectly satisfied to leave his Treatise, as formerly, to the unbiassed judgment of an impartial Public, which he is conscious can never fail, ultimately, to decide with the most impartial justice.

INTRODUCTION.

THE principal part of the following Eſſay was firſt publiſhed in the year 1755, exactly as it now appears, (verbal corrections excepted) and had paſſed through three editions before the year 1795, when the Preſident of the Board of Agriculture brought forward a motion in parliament, to obtain a premium of 1000*l.* to be given to one Mr. Joſeph Elkington, for *diſcoveries* ſaid to be made by him in the art of draining land. This naturally called the attention of the author to a ſubject, on which he had formerly written himſelf; and from the particular enquiries he made, he found reaſon to be ſatisfied, that the only particular in which Mr. Elkington's mode of draining differed from that practiſed in general throughout Britain, conſiſted in what he called, *tapping* for ſprings, a mode of draining which had been practiſed by the author more than thirty years before, and which had been particularly

 deſcribed

described and illustrated by figures in the first edition of these Essays. On this occasion, without any intention either to frustrate Mr. Elkington of his premium, or to claim any gratuity to himself, the author thought it expedient, politely by letter, to inform Sir John Sinclair of the mistake he had inadvertently fallen into, in ascribing that practice, as *an original invention*, *exclusively* to Mr. Elkington, and producing a quotation from this Essay, as a decisive proof that it was not a new thing. Sir John Sinclair, without adverting to those facts, chose afterwards to state, in two separate publications, in the most decisive manner, his opinion of the undoubted right that Mr. Elkington had to claim this invention *exclusively* as his own. This drew from the author a second letter to Sir John, in which the justice of that decision is controverted, and in which the author calls upon the Board of Agriculture to publish an account of Mr. Elkington's mode of draining, that the public may be enabled to judge impartially in this case. These two letters are here subjoined for the purpose

pose of more clearly elucidating this subject.

TO SIR JOHN SINCLAIR, BART.

PRESIDENT OF THE BOARD OF AGRICULTURE.

LETTER FIRST.

Canfield, near Edinburgh,
SIR, *30th June, 1795.*

I USE the freedom to trouble you at present, on the subject of draining, adopted by Mr. Elkington, not with a view to detract from the merits of that gentleman, nor to find fault with the remuneration you have obtained for him, but merely to set you right in regard to a matter of fact concerning me, which might easily escape your notice.

I presume, Sir, you thought it evident, from the statement made by Mr. Elkington, that the mode of draining ground, which has been so successfully practised of late, by that gentleman, was an invention peculiarly his own. That this is not the

case, admits of evidence, which, I hope, you will allow to be satisfactory. It is now twenty years since I published a book, called *Essays relating to Agriculture and Rural Affairs.* If you will take the trouble of turning to the second Essay of that work, which is *On Draining Bogs and swampy Ground*, you will there find the method of draining by means of *tapping*, which has been adopted by Mr. Elkington, fully explained, and the principles upon which it may be practised, clearly developed, by the aid of illustrative figures, discriminating plainly the cases in which that mode of practice would be improper.

I do not understand that Mr. Elkington practised this method of draining before the publication of that work (anno 1775) neither do I mean to assert that he adopted the practice from the directions there given. I readily admit that the principle is so simple, and so obvious to every considerate mind, that it would certainly be nothing extraordinary, if he, by his own reflections alone, should have discovered it, as well as I did. There is only one particular

particular in his mode that I myſelf had not practiſed before that Eſſay was publiſhed, viz. the making the tapping by means of *a boring inſtrument*; but even this I have particularly deſcribed, as you will find in the following words, at page 181 (*Third Edition, Vol.* I) of the foreſaid Eſſays. After deſcribing the mode of tapping I had adopted, by ſinking ſmall pits, and explaining the caſes in which it may be ſucceſsfully practiſed, it is added, " I have often imagined that the expence of digging theſe pits might be ſaved, *by boring a hole through this ſolid ſtratum of clay, with a wimble (an auger) made on purpoſe*; but as I have never experienced this, I cannot ſay whether it would anſwer the deſired end exactly."—Neither can I *now* ſay, whether Mr. Elkington grounded his practice on this hint or not; but I may ſafely ſay, if he did not, he might have done it: And as I could not have borrowed it from him, if there be any merit in the *diſcovery*, I have aſſuredly a juſt title to claim it.

I wiſh not to throw out any inſinuation to the prejudice of Mr. Elkington, who,

by a proper degree of management on his part, has great merit in having turned the attention of the nation towards a mode of draining, which, if the principles upon which it is grounded, are fully underſtood, and properly applied, will be found to be equally cheap and efficacious; as I myſelf, from an experience of it for more than thirty years, can ſafely aſſert. But it is a miſtake, to think it can be univerſally applied. There are many caſes in which it can be of no uſe, and, therefore, it were vain to attempt it; as I have fully demonſtrated in the Treatiſe referred to.

Whether Mr. Elkington did actually diſcover this mode of draining of himſelf, or adopted it from the very plain directions given in that Treatiſe, is of little conſequence to the Public. In either caſe, he has alike the merit of having introduced it into practice in the ſouthern parts of this Iſland: for the ſimple fact that he has been ſuppoſed to be the firſt inventor of it, is the cleareſt proof that this part of my Treatiſe, *by how many ſoever it may have been read*, has been allowed

lowed to remain, in a great meaſure, a dead letter, even till the preſent hour.

As my intention in publiſhing that Eſſay, doubtleſs, was to benefit the public, I owe, perhaps, thanks to Mr. Elkington, for having thus forwarded that deſign. It is not impoſſible that the time may not be far diſtant, when I ſhall be laid under a ſimilar obligation to ſome other perſon, for bringing into practice, *as a new invention*, the mode of embanking rivers, which is deſcribed in the Eſſays referred to, with a ſimilar degree of clearneſs; and which, when reduced into practice, will be an improvement equally cheap and efficacious with the above. An obligation of this ſort was conferred upon me, ſome years ago, without my knowledge of it at the time, by a Mr. Brodie, I think the name is, when he brought into notice, what he called, the *Patent Bath Stove*; the principle upon which that ſtove is conſtructed, having been explained, and clearly illuſtrated by means of a plate in a Treatiſe of mine "On Smoky Chimneys," that was firſt publiſhed in the year 1769; but this particular was little adverted to for

ſeveral years, till Mr. Brodie, by a *little proper management*, brought it into notice‡. My ideas, freely communicated to the public, have been a ſource of emolument or of honour to others alſo—my own reward has been the ſatisfaction of having done what I know to be right, and the *honour* of being indirectly flattered by compliments that were publicly appropriated to others.

Wiſhing you ſucceſs in your laudable undertakings, which, if properly ſupported, cannot fail to be attended with effects highly beneficial to the nation, I have the honour to be, with due reſpect,

Sir,

Your moſt humble ſervant,

JAMES ANDERSON.

‡ It is generally believed that Mr. Brodie has realized a hundred thouſand pounds by this contrivance.

LETTER

LETTER SECOND.

Cotfield, near Edinburgh,
10th January, 1796.

SIR,

SINCE I had the honour of addreffing you in public on the fubject of draining land, I have learnt that a controverfy has been carried on in the Newfpapers to fome length, upon the fame fubject, by various perfons. Who thefe perfons are I know not; and with the particular object that each party has in view, I am in a great meafure unacquainted. I never faw one of thefe publications (except two, which accidently fell into my hands in September laft, when I paffed through London). The prefent letter, therefore, muft be confidered as having no connection with, or reference to thefe publications; and if any thing fhall here occur that fhall tend either to corroborate or oppofe any of thefe writings, it muft be confidered as merely accidental.

Since my own letter, above alluded to, was written, I have feen two publications, by the Prefident of the Board of Agriculture, in which the draining of land has been mentioned. The firft is an Addrefs to the

the Board of Agriculture, dated 14th July, 1795, in which it is taken notice of in these words: 'The Board has succeeded 'in its first application [i.e. to Parliament for a reward on account of *discoveries* advantageous to Agriculture] in behalf of a 'very deserving individual, Mr. Joseph El-'kington, *who has carried the art of draining* '*to a perfection hitherto unknown.*' The second is an Address to the Board of Agriculture, on the cultivation and improvement of the waste lands of *Great Britain*, by the President, printed 23d December, 1795, in these words: 'A considerable 'proportion of the wastes of Great Britain 'consists of lands of a wet and boggy na-'ture, which it has been yet supposed was 'the most difficult to improve and cultivate. 'Fortunately, however, *discoveries* have been 'made in the art of draining such bogs, 'by Mr. Joseph Elkington, a farmer, in the 'county of Warwick, as renders the im-'provement of swampy land a matter of 'much less difficulty or expence than for-'merly.' My friends think that in both these passages there is manifestly a *marked* determination to set aside my claim

to

to any ſhare in the diſcovery of that mode of draining, and a ſtudied care to avoid my name in any way, leſt it might imply ſome ſort of derogation from the merit of Mr. Elkington; and they farther think, that after the public claim I have already made to that diſcovery, it would argue little leſs than a conſciouſneſs of the injuſtice of my claim, ſhould I ſuffer ſuch a public affront to paſs unnoticed. As ſome of Sir John Sinclair's beſt friends with whom I have ſpoken upon the ſubject concur in the ſame opinion, I find myſelf called upon to urge a farther explanation on that head; which is one of the principal objects of the preſent Addreſs.

The queſtion at iſſue may be reduced to a very narrow point, which is this: The practice of Mr. Elkington is, in its principle, either the ſame with that which was practiſed by me, more than thirty years ago, and the principle of it developed and clearly illuſtrated by figures, in Eſſays relating to Agriculture and Rural affairs, which were publiſhed in the year 1775; or it is not. If it be the ſame, then, doubtleſs, Mr. Elkington can have no juſt title

to

to be held out to public view, *exclusively*,' as the discoverer of this practice; for I presume, he will not allege that at the time of the discovery, I had ever heard of him or of his practice. Indeed, I never did hear of either, till his name was first mentioned in some of the publications of the Board of Agriculture. On the contrary, as it is certain that my discovery was published more than twenty years ago, and that Mr. Elkington has never till this hour published his, but has been going on from imperfect beginnings, gradually improving as he went on, it is not so clear that he may not have borrowed some hints to direct his practice, either directly from my treatise, which has been pretty generally read in Lancashire, or from the conversation of some persons who had read it. From these considerations, if the principle be the same, it will be difficult for the President of the Board of Agriculture, to clear himself from the imputation of a marked partiality in the passages above quoted; especially after my having pointed out to him, in my former letter, the passages in my

my Eſſays, that directed the ſame method of practice ſo long ago, as has been already ſpecified. If, on the other hand, the practice followed by Mr. Elkington differs in principle from that which I had ſo long ago explained; in that caſe, the Preſident of the Board of Agriculture may be with reaſon accuſed of injuſtice to the public, by having delayed ſo long to explain the principle of that uſeful diſcovery; for, as the public have already paid for the diſcovery, they have a right to demand that it ſhould be made more generally known for the benefit of the whole community, in the ſame manner as Mr. Forſyth's receipt for recovering decayed trees was publiſhed, on receiving his premium. I therefore, in the name of the public, demand of you, Sir, who have taken the lead in this tranſaction, to publiſh this ſecret, that all the world may be enabled to know it, and to avail themſelves of it, if they incline, without being obliged to have recourſe to Mr. Elkington himſelf, who in this inſtance, like the venders of quack medicines, carefully conceals his ſecret, that he may be enabled to pro-

fit by the credulity of the public: And shall the President of the Board of Agriculture, demean himself so far, as to give countenance to such transactions!!!—I will not suppose, that such can be the case. Yet appearances are against you. —Inadvertence may have led you to adopt a language that is fairly susceptible of that interpretation; and you cannot take too early an opportunity of doing it away.

It will be the easiest thing imaginable for Sir John Sinclair to clear himself from this charge, and settle the matter,—simply by publishing the principles on which Mr. Elkington's method of draining is founded. This can be attended with little trouble:—For as Sir John must fully understand the principle himself, (otherwise it would be an insult to suppose he could have adopted a language so strong and decisive as he has done)—he can find little difficulty in explaining it, as a supplement to one of those publications that are every day issuing from the press, at the expence of the Board of Agriculture.

Such

Such a publication is likewiſe neceſſary on Mr. Elkington's account, if he means to free himſelf from the imputation of quackery; which idea, the manner in which he has been introduced to public notice, by the Board of Agriculture, has a ſtrong tendency to countenance. This ought to be done away, if he wiſhes to gain that reſpectability of character, to which ſuperior talents ſhould naturally entitle him. With ſuch men, *candour* is ever a leading characteriſtic feature; for, however far concealment and deception may lead to emolument in certain caſes, it never can be accounted honourable. Now, if Mr. Elkington is ſenſible, that he underſtands the principles upon which his practice is grounded, ſo completely as to be able to explain it in ſuch a ſatisfactory manner, as to ſet at defiance the critiques of philoſophical inveſtigators, he can have no objections to publiſh it. He has received a price for it; and not only honour calls for it, but *juſtice* requires it at his hand. If neither the Preſident, nor any other member of the Board of Agriculture, nor Mr. Elkington himſelf, ſhall, after being

thus called upon, publiſh the ſecret that he has ſold, the public will be diſpoſed to believe that Mr. Elkington cannot do it, and that he has availed himſelf of the influence of ſome great man, to impoſe upon the Preſident and the Board of Agriculture, who have thus, in their turn, been induced to lend their aid to enable him to diſpoſe of his noſtrum to the beſt advantage. From theſe conſiderations, it alike behoves the Preſident, the Board of Agriculture, and Mr. Elkington himſelf, to loſe no time in publiſhing his ſecret. Among other good effects that will reſult from this meaſure, it will totally preclude all farther altercation reſpecting the merit of this diſcovery between him and myſelf, or others.

Till ſuch publication appears, it may not be improper in me to obſerve, that another body of men, who have had good opportunities of information, have thought proper to adopt a conduct, reſpecting this particular, very different from that of the Preſident of the Board of Agriculture. The gentlemen who compoſe the Society of Agriculture, at Altringham, near Mancheſter,

chester, in the county of Lancaster, having determined to encourage the draining of land by means of tapping, judged that a respect for their character required them, in this case, to act with the strictest impartiality: And thinking it would be of use to those who were to attempt it, to know the principle on which success depended, as well as the mechanical practice of the art, the Society offered a premium to those who drained the greatest quantity of land, 'according to the practice followed by Mr. Elkington, on the principles explained by Dr. Anderson, in a book called Essays relating to Agriculture and Rural Affairs.'

The following is Mr. Elkington's own account of the way in which he was first led into the train of discovering his mode of draining by means of tapping, as it was told to me by a gentleman of great veracity, who had it from Mr. Elkington himself; and it appears to be so natural, as fully convinces me that it is strictly the truth. Mr. Elkington's father having died about the year 1763, left him in possession of a small farm of wet sour land.

He found that no good could be made of it without previous draining. He accordingly set to work to drain it in the usual way; but after having laid out as much money as his narrow funds could afford, he had the mortification to find that no benefit had resulted from his labour; which tended very much to discourage him. While he was in a state of despondency on this account, he, by accident, dug a little deeper than usual in one of his drains, and found, to his great surprise, that a copious spring of water burst forth from the hole, which continued to flow with a plentiful stream for a very long period of time. He dug deeper, in several other places, with the same effect, though the streams were less copious than the first. In consequence of these openings, he had the satisfaction to perceive, that his fields gradually became drier and drier, till they at last were perfectly freed by it from all the superfluous moisture. And not only were his own fields thus drained, but the contiguous land, for a considerable distance all round, was made drier also by the operation. This circumstance led him

to

to suspect, that in other cases, where the surface appearance of wet land was somewhat similar to his own, they might be drained by making openings resembling those above named. Success attended his operations in many cases; and he gradually went on in his practice, correcting his first errors by experience, and improving upon it till the present time.

From this account, it would seem that the discovery was, as to him, merely accidental; nor does it appear, from the above, that he had any clear idea of the manner in which the draining is thus effected, or the principles on which it depends, so as to be able to distinguish *à priori*, those cases in which that mode of draining could be of no use, from those where it must of necessity prove efficacious.

As to myself, the discovery of that mode of draining was made in the following manner: I had a field of wet land that lay very flat, but so surrounded by ditches, that no surface water could come to it from higher ground any where, and possessing at the same time such a level as to prevent any water from necessarily stagnating upon

it. The field was ſo wet, that in many places it was a mere hobbling bog, over which a man could ſcarcely paſs during the drieſt weather in ſummer. This was a very unprofitable as well as diſguſtful object; and, in the beginning of the year 1764, I ſet about ſeriouſly to have it drained. On conſidering the circumſtances of the caſe with attention, I ſoon perceived that as no *ſurface* water could come upon it from the higher ground; and as the rain that fell upon the field itſelf was ſuffered freely to run off, the water that drowned it muſt riſe up from *below*. But as the weight of the atmoſphere acted on this field as well as on thoſe around, the water could not be made to aſcend, as in a pump, by means of ſuction: it muſt, then, be forced to take that direction in conſequence of ſome powerful preſſure from below ground, acting ſo ſtrongly as to overcome its natural gravity. This preſſure, it was evident, could only be in conſequence of the water flowing from higher ground, *under the ſurface*, through a ſtratum of pervious matter, being pent in near the bottom,

bottom, by a ſtratum of clay placed above it, and thus forced to riſe to a higher level, than the low ground, in this kind of ſubterraneous canal, ſo as, by the natural power of gravity, to be ſqueezed forcibly through ſmall fiſſures in the ſuperior ſtratum of clay. If ſo, it would neceſſarily follow, that ſhould a hole be dug through the ſuperincumbent ſtratum of clay, ſo as to reach the bed of the reſervoir, the water would be allowed to iſſue freely through that opening, and to run off the ground by its natural level; and thus would the accumulated water, which occaſioned the preſſure, be gradually diſcharged, after which, it could no longer be forced up through the ſmall fiſſures in the clay; and, of courſe, the wetneſs, which had ariſen ſolely from that cauſe, muſt be gradually removed. On this reaſoning, which ſeemed perfectly concluſive, and which was confirmed by obſerving that the ſubſoil of that field was every where a very ſtiff clay, mixed with ſmall ſtones, the dry weather was no ſooner ſet in, than I put a man to dig a pit as near to the

edge of the ſwaggle as he could approach, ordering him to penetrate directly downwards, making the pit no larger than was ſufficient to allow him to work, and to proceed without interruption, until he ſhould perceive that, on making his ſtrokes, it ſhould ſound as if it were ſomewhat hollow below. On obſerving this, he was deſired immediately to deſiſt, until he called me, and received farther orders. The labourer accordingly fell to work; but he found the ground ſo hard, that, in the courſe of two days, he had only penetrated to the depth of about five feet. During that time, I frequently viſited the work, to examine appearances. Nothing remarkable occurred, ſave that little peering ſprings often were diſcovered, through which the water iſſued; but the quantity of water that came from them was not ſuch as to interrupt the work. On the morning of the third day, about breakfaſt time, the labourer called on me, and ſaid, that as his ſtroke gave a *douf ſound*, (that was his phraſe) he had called me, according to my deſire. I went immediately with him to the place, and having

made

made him go down into the pit, I desired him to show me in what manner he could come out of it. He then pointed out to to me, a kind of steps he had made into the clay on one side; and having lent him my hand to assist him, I found he could get out very quickly. I then ordered him to take a kind of sharp-pointed iron crow, with a cross handle and foot to it, which he had found a very useful tool in loosening the clay, and give a stroke of that with all his force upon the bottom, which he did.—On this, to his great surprize, the tool penetrated a thin crust, and then fell down, from one to two feet, as in a vacuity. Through the opening thus made, a strong jet of water rushed instantly with great impetuosity; but I, being aware of it, and at hand to assist the man in mounting, he got very quickly to the surface, and out of all danger, though not a little terrified at what had happened. The stream was at first so large, as might, I suppose, have filled a pipe of from six to twelve inches diameter; and rose, as a *jet d'eau*, to the height of six feet at least, above the surface of the ground. The labourer, who had no idea of such a phe-

nomenon, looked upon it with an overpowering aſtoniſhment, which would have furniſhed a fine ſubject for the painter. The ſtream continued to flow, and to riſe above the ſurface of the ground for about a week; but gradually abated in height, till it aroſe not above the ſurface of the ground, and continued ſtill to flow; but the quantity of water gradually diminiſhed, till it at laſt ſettled into a perennial ſpring, which continues to run till the preſent day.

The conſequence of this operation was, that during the courſe of the enſuing ſummer, the water gradually drained off from the boggy ground; the ſwaggle ſlowly acquired a firm ſurface, ſo as to admit of being ploughed at any ſeaſon; and about twenty acres of ground were thereby drained, which, before that time, had been, in a great meaſure, uſeleſs for every agricultural purpoſe.

Ten years afterwards, being about to publiſh an Eſſay, containing directions for draining all the different kinds of wet grounds that occaſionally prove detrimental to the farmer, I naturally ſpecified this variety of wet ground among the others, and gave a plate explanatory

explanatory of the cauſe of that phenomenon, as I had done of the others, in order that every perſon who choſe it, might be enabled to diſtinguiſh the caſe, and apply the remedy himſelf, if he ſo inclined. The Eſſay has been now in the hands of the public above twenty years, and will ſpeak for itſelf; ſo that more need not be ſaid here on that head, farther than that all theſe facts could be *proved*, were it thought neceſſary to do ſo.

I may add, however, at preſent, when I find that a diſpoſition is manifeſted, on ſome occaſions, to withhold honour from thoſe to whom honour is due, that though I did not think it proper in a work that profeſſedly treated of agricultural concerns only, to ſpecify all the uſeful corollaries that might be drawn from the phyſical appearance above explained; I may now, without any impropriety, barely mention, that from the application of this principle, many phenomena may be explained in a very ſatisfactory manner, which have been hitherto reckoned caſes of great difficulty. Some of theſe, (particularly the caſe of a well that was ſunk at Tilbury Fort, on the Thames, as narrated

rated in the Phil. Tran. Vol. in which an abundant ſpring of *freſh* water was found, at a great depth below the ſurface of the ſea, after two ſprings of *ſalt* water had been paſſed through above it) I pointed out, in a letter I did myſelf the honour to write, ſeveral months ago, to Leigh Philips, Eſq. of Mancheſter, who had been kind enough to ſay, that the eſſay refered to, was what he conceived to be a *complete ſyſtem of draining*. This expreſſion induced me to ſhow him it could not be deemed *complete*; as ſeveral caſes were omitted, which I then ſpecified to him: among others, it was ſtated that deep lakes, ſurrounded by mountains of great height on all ſides, may, on ſome occaſions, be entirely drained, by *boring*, or ſinking ſhafts downwards, ſometimes to a moderate depth: That alſo, wet-land may, on ſome occaſions, be more eaſily drained, by opening an outlet for the water *beneath* the reſervoir which occaſions the wet, than by bringing it up to the ſurface. And that among mountains, it may frequently be much cheaper to carry off ſuperfluous water from mines, by penetrating downwards, than by driving a horizontal

level to the surface of the ground, which is in many cases attended with a ruinous expence. These corollaries are indeed so obvious, when the principle is once explained, that it must appear astonishing to any considerate mind they have not been made, and very generally applied in practical cases, long before the present period; and I here specify them, merely to direct the attention of men to an object from which much practical good may be derived, in a variety of cases, which it would be tiresome in me here to enumerate.

I have farther to add, on this head, that there is one variety of wet ground which had totally escaped my notice in that Essay, and which has not, that I know of, been treated by any writer on agriculture; though it is perhaps more universally hurtful to the farmer, than any other kind of wet land whatever. This I shall have occasion particularly to explain, in a treatise now in the press, on the improvement of waste lands.

From the facts that were stated to the committee of the Board of Agriculture, in favour of Mr. Elkington's mode of

draining,

draining, as publiſhed in their *report*, dated June 5th, 1795, there ſeems to be reaſon to ſuſpect, that Mr. Elkington himſelf, even at that period, was not fully aware of all the circumſtances that were eſſential to the practice of draining ground, in the moſt economical manner, by means of tapping;—as the labour and expences incurred, in many of the caſes there ſpecified, ſeem to be much greater than that mode of draining, judiciouſly applied, could poſſibly have required. But as theſe caſes are ſtated by gentlemen who did not themſelves fully underſtand his method, they may poſſibly have been done with ſome degree of inaccuracy. When Mr. Elkington himſelf ſhall publiſh his own method, that doubt will be removed; and every individual will then be able to judge for himſelf as to this particular. If his practice be as good as it is ſaid to be, it cannot be too ſoon or too generally made known. If it ſhall be defective in any reſpect, theſe defects cannot be too ſoon pointed out and rectified; which would probably not be long delayed after the publication required.

I ſhall be ſorry, if, in conſequence of the precipitate conduct of Mr. Elkington's friends, I have been obliged, for the purpoſe of obtaining impartial juſtice, to ſay any thing here that may tend to prove, in the ſmalleſt degree, detrimental to that gentleman. I look upon him as a very worthy member of ſociety; and I believe him to be an honeſt man. I have not a doubt but his practice has already been of much national utility, and will be of ſtill more, the wider it is diffuſed; even although it ſhould not be carried on in the moſt perfect manner of which it will be found to be ultimately ſuſceptible: and I can aſſure that gentleman, with much ſincerity, that there is not a man in the land, not the Preſident of the Board of Agriculture himſelf, nor his ſtill more powerful patron, who will rejoice more in his proſperity than myſelf, or who would more gladly lend his aid to the extending his practiſe as wide, and the rendering it as perfect, as poſſible. It is, perhaps, unfortunate, when a plain man finds himſelf forced to come forward in the genteel circle,—eſpecially where ſuch perſon

may,

may, by the ill-judging partiality of ignorant friends, be induced, from the hope of benefiting his family, to acquiesce in statements that he himself would never perhaps, have made, even though he be backed by those who have the most powerful influence: For it is not in this nation, that influence can altogether suppress the voice of reason, or ward off entirely the severity of reprimand, when the influence of supposed power provokes a scrutinising enquiry.

I have now, Sir, done with the business of Mr. Elkington, but am sorry, that, in justice to myself, I am not yet at liberty to put an end to this, I fear, ungracious epistle.

It appears to me very strange that I should have occasion, at one time, to complain of having been ill used in *two* respects, by Sir John Sinclair, as I am not, conscious of ever having merited any thing of that sort at his hand, *but much the reverse*. It unluckily happens to be so, however, at present. The trespass, too, is of such a kind as to require that notice should be taken of it in the public manner

I now

I now do, in order that I may remove, in part, at leaſt, the injury that, by his improper conduct, muſt have been done to my character. I ſhall briefly ſtate the facts, for the juſtneſs of which ſtatement I appeal to yourſelf.

Immediately on receiving a letter from the Preſident of the Board of Agriculture, in February laſt, requeſting that I would favour the Board with any information I could give reſpecting the culture and uſes of Potatoes; I ſat down, and in great haſte, put upon paper ſuch obſervations as occurred to me at the moment. Theſe obſervations, without reviſal or corrections, were inſtantly forwarded to the Board, under cover, addreſſed to the Preſident, and were accompanied by a letter, ſtating that I had loſt no time in complying with the wiſhes of the Board reſpecting the ſubject of Potatoes, and that the papers which accompanied that letter, contained what appeared neceſſary for me to ſay on that head. But, I added, that theſe remarks were intended ſolely for the uſe of the Members of the Board itſelf, and "were not intended to be *publiſhed.*"

This

This I forbade in the most positive manner; and even requested that the Board would be so kind as not to mention my name, in any publication they might think proper to make on that subject; desiring that the papers might be returned to me, after the Members of the Board had satisfied themselves with regard to them. So anxious was I that this requisition should not be forgotten, that I mentioned it no less than three times, in as many different letters I had afterwards occasion to write to Sir John Sinclair; and as the franks had been reduced in weight before the last letter was written, I desired him, with a view to avoid the trouble of addressing so many covers as it would then require, to send the MS. to my son in London, who would take care to get it forwarded to me. After all this, the reader will judge of my surprise, when I read these words in a letter from Sir John: 'The Board has at 'length finished its publication, on the sub'ject of Potatoes; *and as you have been a 'contributer to it*, you are entitled to a copy 'of it.' In what manner I had become a contributer to that work, I could not well

conceive; for I did not then imagine, that ever he could think of publiſhing what I had ſo poſitively forbidden: but as ſome obſervations of mine on Potatoes had been printed in other publications, I thought ſomething might have been extracted from theſe works, to which this paſſage might allude. I took the earlieſt opportunity that offered, to conſult that work for my own ſatisfaction. My aſtoniſhment at ſeeing the obſervations printed entire, with all their faults, and others ſuperadded, and thus forced upon the public notice, "unanointed, unanelled;" and the indignation I felt at this unexpected inſult, may be eaſier conceived than expreſſed. I call it an inſult, becauſe I conceive that no one acting in the character of a gentleman, can have a right to publiſh the writings of another, even without his conſent, far leſs, if contrary to his expreſs injunctions, clearly announced, and repeatedly enforced. You, Sir John, have it in your power, by publiſhing my letter, to correct, me if I miſrepreſent the fact. If I have ſtated it juſtly, it is incumbent upon you to make ſuch an apology, as one gen-

tleman ought to give, and another to receive.

What adds *injury* to the *insult*, on the present occasion, is, that from the whole tenor of the writing, it was obviously intended for private information only, and not at all for the public use; and if you had taken the trouble to read, with an ordinary degree of attention, the first sentence only, you could not have failed to perceive it. You need scarcely be told it may be extremely proper to express in a particular way, what was obviously calculated for the private perusal, of a few gentlemen only, who were about to judge of matters that were not within the sphere of their observation; though it would be exceedingly preposterous to make use of the same expressions, when intended to be laid before the best-informed professional men in the kingdom. The observations which, in the one case, would only be calculated to induce that cautious circumspection which men of professional knowledge, in any line, are in some measure required to use, when called upon to assist those

thoſe of leſs experience, whoſe ſituation in life incidentally may bring them to decide in matters reſpecting that profeſſion; but, in the other caſe, as being addreſſed to profeſſional men, many of whom may be ſuppoſed, to be equally well informed as the writer himſelf, could be conſidered as little better than an inſult, and would indicate an overweening preſumption in the writer, that could only excite diſguſt and contempt. Such, in fact, is preciſely the caſe in the preſent inſtance; and the words of the introductory paragraph to that Eſſay, if they were ſuppoſed to be intended for publication, can only be calculated to make an impreſſion on the mind of every reader, that is very little in favour of the writer; and what I conceive to be extremely different from what my own character, if not obſcured under ſuch an humiliating diſguiſe, ought naturally to produce. I feel, at leaſt, that if any other perſon had written ſuch a paragraph, intending it to be publiſhed, as this has been, I ſhould have deſpiſed him as an impudent coxcomb, whom it would be a merit to humble. Sir John Sinclair, is

as capable as any man of judging of the irreſiſtible effects of ſuch impreſſions on the public mind; nor would there have been any thing extraordinary in it, if he had, on receiving ſuch a paragraph for publication, from a man with whom he was in habits of intimacy, requeſted him to reconſider it, to ſee how far he thought it proper for the public eye, on the ſuppoſition that it had eſcaped his notice through inadvertency. But to publiſh it in that imperfect ſtate, though contrary to the expreſs orders of the writer, repeatedly enforced, without giving him even a hint of ſuch an intention, was uſing a freedom, which no man, whatever his ſituation in life may be, has a right to take with another. The law has provided a puniſhment for him who injures his neighbour's good name. The injury may be as great when it is done in this way as any other, though it has, perhaps, hitherto eſcaped the notice of legiſlators. With thoſe who ſhall read this letter, perhaps, *a part* of the injury may be done away; but Sir John ought to conſider that thouſands may have ſeen the publication al-

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luded to, who may never have an opportunity of reading this, and that the writer muſt continue to be deſpiſed by them till the end of time.

Beſides the circumſtance above alluded to, there are other blameable particulars, originating from the publication of that performance, by the Board of Agriculture, that muſt affect the character of the writer; for ſo little attention has been paid to the printing, that from the incorrectneſs of the preſs, he muſt, in ſome caſes, appear to write in a manner altogether unintelligibly, and, in others, he is made to ſpeak perfect nonſenſe*. I will not ſay that theſe things were intended: But is it fit that one perſon ſhould ſuffer a material injury, through the careleſſneſs of another; eſpecially when that is produc-

* EXAMPLES. I had ſaid, 'But now *that* freſh 'kinds are obtained from *ſeeds*,' which is printed, 'But 'now *the* freſh kinds are obtained from *reds*.' I had ſaid, 'Nor are thoſe kinds that ſend their bulbs deep in 'the ground, ſo *deſirable* as thoſe that riſe upwards,' which is printed, 'ſo *durable* as thoſe that riſe upwards.' I had ſaid, that in a rich mellow ſoil, 'the roots would be able 'to ſtrike with eaſe, and *find* abundant nouriſhment;' it is printed, 'and *ſend* abundant nouriſhment.'

ed, not in the ordinary courſe of buſineſs, but is occaſioned entirely by the culpable forwardneſs of that perſon?

I am happy at being now come nearly to the cloſe of a letter, the writing of which has been to me a very unpleaſing taſk; for I mean not to bring forward any other complaints againſt you, at this time; and hope I never ſhall be forced to do ſo, at any future period. I do not take pleaſure in finding fault; and in few caſes could it prove more irkſome to me than the preſent. Anxious as I have been, through the whole courſe of my life, to ſee the proſperity of this country augmented, by promoting the peaceful exertions of rural induſtry, and thus preſerving the morals of the people untainted, the only ſure baſis of national welfare; I cannot but feel a ſenſible regret, at any degradation of the character of the man who has taken the lead, for the preſent, in that laudable undertaking. Undoubtedly, nothing tends ſo much to exalt a man's character, and to give him ſuperior weight on all occaſions among his equals, as that unbiaſſed integrity, which, riſing

above

above thoſe partialities and prejudices that are inſeparable from little minds, preſſes ſteadily forward in its courſe, without wavering, however aſſailed by the tempting lures that may be held out to it, on either hand, by the artful and deſigning. It was this that raiſed Ariſtides, the Athenian, to that exalted pre-eminence which ſuppreſſed even competition itſelf, and gave him ſingly the power of adjuſting the claims of rival ſtates. Such a character commands reſpect, even where talents are rather defective; and will make errors themſelves be overlooked by moſt men: but where this divine attribute is wanting, the moſt brilliant talents diſplay their luſtre in vain; and even the moſt uſeful purſuits, by ſuch men, are fruſtrated. I have been hurt, Sir John, at the obvious partiality of your conduct towards myſelf, and the apparent deſign, unfairly, to leſſen my character with the public. Should a ſimilar weakneſs, to uſe the mildeſt expreſſion, be perceived in regard to others, the influence of the Board of Agriculture muſt ſoon be loſt with the public. It will only be then viewed as one of

those tiny institutions, that are calculated to soothe the vanity, or to augment the political influence of certain individuals for the time. I most anxiously wish that this may never be the case; and shall only add, that if any thing I have here said, shall, by inducing a little more circumspection, where the reputation or the interest of others may be affected by any casual inattention on his part, tend to render the character of Sir John Sinclair, still more respectable than it has hitherto been, it will add to the pleasure and happiness of

Sir,

Your very sincere well-wisher,

JAMES ANDERSON.

Whether it was in consequence of the demand above made, or from any other motive, the author cannot say; but in the news-paper called the *Sun*, for June 3, 1796, the following account of Mr. Elkington's mode of draining was published. As soon as he heard of it, the author took the earliest opportunity of reading it, which he

he had no ſooner done, than he repented him of having, in ſome meaſure, pledged himſelf in that letter, to make ſome remarks upon it. Writing, where one finds little to commend, is but a very unpleaſing taſk. On the preſent occaſion, it became peculiarly ſo, becauſe the honeſt man, againſt whom would ſeem to apply, any cenſure that ſhould be made, appears himſelf to be abuſed.—No wonder, then, if the taſk was undertaken with reluctance, and as long delayed as poſſible. When about to publiſh the preſent edition of theſe Eſſays, however (Feb. 1797) the author thought it incumbent on him, after what had paſſed, to take ſome notice of this publication; and with that view, he read it over with greater care than he had done before, which enabled him to perceive, that he could happily get rid of the taſk; for, unleſs it be in a very few particulars indeed, he finds, that from the moſt painful attention he could beſtow upon it, he has ſcarcely been able to collect a ſingle conſiſtent idea from the peruſal of that performance.—At the firſt curſory reading, he believed, indeed, that he ſhould be

able

able to make ſomething of it; but afterwards he found, that in proportion as the paſſages were examined with care, theſe naſcent ideas evaniſhed. He now, therefore, is forced candidly to acknowledge, that he cannot collect, *from this paper*, any thing that can deciſively ſhow, whether Mr. Elkington's mode of draining be the ſame, or different from his own. That the reader may judge for himſelf, however, in this caſe, and that the preſent Treatiſe may be made as complete as poſſible on this ſubject in itſelf, that paper (which is not very long) is printed entire, with as ſtrict an attention to accuracy as he could beſtow. It is, however, ſo far fortunate for Mr. Elkington, that it does not appear to be written by him. Indeed, it bears internal evidence ſufficient to prove, that it never could have been written by him, or by any one who had actually *practiſed* draining.

MR. ELKINGTON'S MODE OF DRAINING.

EXTRACTS *from the* MINUTES *of* PROCEEDINGS *of the* BOARD OF AGRICULTURE, *respecting Mr.* ELKINGTON'S *Mode of Draining Land.*

"It is a circumſtance hardly to be credited, that the principles on which the draining of land depends, ſhould have remained ſo long unaſcertained, conſidering the great private benefit, and the many public advantages, which muſt neceſſarily be derived from carrying ſo important an art to perfection.

"The following narrative will explain the circumſtances, that led to ſo valuable a diſcovery; which, however immaterial in themſelves, it was thought right to preſerve, as a proof, among many others, how trifling incidents may produce very important conſequences:

"About 30 years ago (anno 1763-4) Mr. JOSEPH ELKINGTON, then 22 years of age, took a farm, called Princethorp, containing nearly 200 acres, ſituated in the pariſh

riſh of Stretton upon Dunſmore, in the county of Warwick.—The pariſh had been lately incloſed by act of parliament, but the farm he poſſeſſed conſiſted chiefly of poor quality, not being worth more than ſix ſhillings per acre. It was extremely wet; and finding that it rotted his ſheep, he determined, if poſſible, to drain it.—The field in which he began was of a wet, gravelly nature, and full of ſprings. In order to drain it, he dug a trench, from four to five feet in depth; but after proceeding with it for about 100 yards, he found that no water entered the trench, and conſequently that he had not hit upon the ſpring which occaſioned the miſchief. A thought accidentally ſtruck him, that it might be of uſe to know what kind of ſtrata lay under the trench, whether hard or ſoft, and how near it lay to the rock. He got an iron-crow, or bar for that purpoſe, about 18 inches in diater (ſuch as the Warwickſhire farmers commonly make uſe of for making holes, into which their ſtakes for fixing hurdles are put). This crow he forced down about three feet into the earth. Upon taking

taking it out, to his aſtoniſhment, a great quantity of water burſt out, and ran down the trench.—This naturally led Mr. Elkington to think of applying an auger, as an inſtrument better adapted for the purpoſe of boring. Upon trial, he ſoon found that to be the caſe; and by following the ſame plan, uſing the auger where neceſſary, he was at laſt enabled to drain all the wet parts of his farm*.

"The

* This account of Mr. Elkington's diſcovery, differs in nothing materially from that which is ſtated in my letter; only it appears, that the preciſe date of this ſuppoſed diſcovery, ſeems to be carefully kept out of view. It is here ſaid, that he *took his farm* (obſerve, it is *took* his farm, not that he *entered* to it, far leſs that he made his diſcovery in draining) in the year 1763-4. For aught that here appears to the contrary, he may have entered into the poſſeſſion of his farm, in the year 1774: for I have known many leaſes of farms *taken ten* or *twelve*, ſome *twenty* years before the entry to them. But to put aſide all appearance of cavilling, let us ſuppoſe that the ambiguous date of 1763-4, means that he *took* it in 1763, and entered to it 1764. I take particular notice of this circumſtance here, becauſe, in the anſwer Sir John Sinclair wrote to my firſt letter, printed above, after apologizing to me, for having obtained a premium for Mr. Elkington, inſtead of myſelf, he ſeemed to conſider the priority of the date of Mr. Elkington's

"The advantages attending the draining of this farm, were very great indeed.

kington's discovery, as the ground on which he must determine. "I am to meet with him (says he) at Wooburn Abbey, on Monday next, when I shall have this circumstance fully investigated, and inform you of it." The publication above, is the first intimation I had of it. Now, by what is here said, it could not be earlier than the year 1764; probably it must have been many years after—for it is said, the farm rotted his sheep, which he could not know, till he had been in possession of it at least one year. From the very next paragraph it appears, that he had not kept it one year only, but several years before he began to drain; for it is there said, "when he first got possession, he lost, *in the course of a few years*, above 800 sheep by the rot." The original discovery, therefore, must have been made by him, not in the year 1764 or 1765, but several years, at least, posterior to these years. Whence comes it, that Sir John should now *studiously* speak with so little precision, to a point that he confessedly considered to be of a most primary importance. I, for my own part, consider it to be of no consequence who made the discovery, if discovery it must be called; for I doubt not, but it had been made by others long before either Mr. Elkington or myself was born:—but a man ought to be consistent with himself. Such disingenuous shifts, to disguise truth, excites contempt for the meanness of the person who adopts them, rather than resentment for the injury intended by them. Through every paragraph in this paper, the same disingenuous effort is clearly discoverable: Might it not be said, in this instance, "the spirit is willing, but the flesh is weak?"

When

When he firſt got into poſſeſſion, he loſt, in the courſe of a few years, above 800 ſheep by the rot; whereas, ſince the farm was completely drained (one ſeaſon alone excepted, when a field that had not been particularly attended to, rotted about a ſcore) his flock has never been affected by that diſeaſe."

On the Principles of Mr. Elkington's Mode of Draining.

"WETNESS of land, in ſo far as it is connected with the preſent enquiry (for it is unneceſſary, on this occaſion, to take any wetneſs into conſideration, if occaſioned by the overflowing of the ſea, or of lakes, or of running water) muſt either proceed from rain-water lying on the ſurface, or from ſprings iſſuing from below.

"No water will remain upon the ſurface, but upon clay, or where the ſubſtratum is clayey, for through the more porous ſoils it naturally ſubſides. Clay, however, being of a tenacious nature, water can

neither paſs through it from the ſurface to the bottom, nor from the bottom to the ſurface. In ſuch land, therefore, there can be no ſprings, and the water that falls on the ſurface muſt remain upon it, unleſs there is a deſcent, and the water is carried down by ſurface-drains, or until it is exhaled by the air, or by the ſun.

" Where the ſurface does not conſiſt entirely of retentive clay, but is porous above, though tenacious below ; the Eſſex or Hertfordſhire mode of hollow-draining may be ſucceſsfully practiſed.

" The object of Mr. Elkington's ſyſtem, however, is, the draining of lands rendered wet by waters confined beneath the ſurface, and attempting to riſe in the manner of ſprings. It is neceſſary, therefore, in the firſt place, to aſcertain the nature of ſprings.

" According to Mr. Elkington's idea, ſprings originate from rain water, ſaved and collected by the hills and riſing grounds ; which water ſubſides through particular ſtrata, and runs either over or under ſuch other ſtrata as are impervious to water, according as they happen to lie,

when

when the water comes into contact with them. He also supposes, that there must be great quantities of water preserved in the bowels of the earth, either in a few or in many reservoirs, according to the extent of which, springs are either temporary, (flowing only in wet seasons, and in general bursting out on the sides of hills) or perpetual, which are chiefly to be found at the bottom.—Where the quantity of water is great, and the orifice or channel small, the water must necessarily flow in equal abundance, at all seasons of the year.

"Springs, he divides into two sorts:—Land-springs, which being supplied by a small quantity of ground (perhaps only a single vein of sand or gravel) must soon run dry; and bog-springs, which being supplied by a hill, or great tract of country, must necessarily be more regular and abundant.

"In regard to the regularity of bog-springs, it is to be observed, that whatever may be the quantity of rain that falls upon a hill, and subsides through its porous soils, or through the fissures of the rocks, and then falls into reservoirs; yet the

quantity of water that iſſues at the ſpring, in any given ſpace of time, muſt depend upon the ſize of the orifice, at or near its mouth; and the velocity with which it flows, is according to its deſcent from a greater or leſſer height.

"There are only four ſubſtances through which ſprings naturally iſſue; namely, 1. Rock, whether conſiſting of ſtone or hard chalk; 2. Gravel; 3. Sand; and, 4. Marle.

"When ſprings iſſue through clay, it can only be in conſequence of the clay being perforated, and upon this circumſtance, in a great meaſure, depends the ſucceſs of Mr. Elkington's mode of draining; for the wetneſs of land, ariſing from ſubjacent water, is in general occaſioned by this, that the water runs under a ſtratum of clay, until it comes either to rock with fiſſures in it, or to gravel, ſand, or marle; it then riſes, or endeavours to riſe, to the ſurface, and in wet ſeaſons overflows the land thus circumſtanced. But if, by perforating the ſtratum of clay, you can intercept the water, and thus prevent its riſing, or can give it an eaſier channel, you

you may then conduct it in any manner that may be thought most advisable, and the land which lies above the bottom of the trench is drained.

"The object of Mr. Elkington's system, therefore, is that of draining land injured by subjacent waters, not by using palliatives, but by obtaining the command of the subterraneous waters themselves, and thus completely, and radically, cutting off the cause of the mischief. Where there is only one collection, or one principal vein, with several smaller ones, this may be done as effectually by one drain as by a thousand.

"The different kinds of soils in which Mr. Elkington has principally worked, are, 1. Clay; 2. Sand; 3. Bogs, or Morasses.

"In many parts of England, there are veins of sand, where the ground is of a clayey nature, and where the soil is commonly called clay, because that substance predominates. In such a soil it is very difficult to work, as it requires a number of trenches, because there is no general mass, but only partial collections of water.

The water is collected in beds of sand or gravel, which, perhaps, may have no communication with each other, being crossed and intercepted by beds of clay; and, consequently, as many trenches must be cut as may be necessary to extract the water from every bed of sand or gravel, each vein of which, if surrounded by beds of clay, becomes a separate reservoir of water; at the same time, there is no impracticability in draining land of that mixed description, though it requires more pains and attention. In this mixed sort of soil the ordinary modes may be successful.

"It is also difficult to drain any field where sand predominates, as the water subsides through it. In land of that description, it is better that the drain should be open, and also very wide, that it may not easily fill up.

"But the great object of Mr. Elkington's system is that of draining bogs; and it is in every point of view the most important; because, in the first place, immense tracts of valuable land, of a morassy nature, are lost to the community, from

from an idea, that it is impoffible to drain them: and in the fecond place, becaufe land of that nature and value, in proportion to its extent, can be drained at the fmalleft expence, and when they are drained, are, perhaps, the moft valuable of any.

" When a bog or morafs is to be drained, the firft object is, to afcertain the direction in which the trench fhould be dug. This is the moft difficult part of the whole bufinefs, as it is hardly poffible to explain it by words or writing, owing to the great variety of bogs, and the great diverfity of countries in which they are fituated.—No man can acquire this art completely without a great deal of practice. Such rules as Mr. Elkington has been able to furnifh, are as follows:

"1. As the whole depends upon the nature of the bog to be drained, and the ftate of the adjacent country, as much knowledge as poffible muft be obtained refpecting the ftrata in the neighbourhood, whether confifting of ftone, gravel, fand, or marle, as the water muft be lodged in one of thefe, and it is neceffary to afcertain which.

 "2. The

"2. The trench muſt be directed ſo as to hit the bottom of the bed which occaſions the miſchief, and the particular ſpot where the main ſpring lies. One ſpring probably occaſions the whole bog, which having no proper vent, forces the water through a number of ſmall veins, even to a great diſtance, and makes the whole a ſwamp. By draining that main ſpring, the others follow of courſe.

"3. If there are various beds through which water iſſues, the ſtone is the one to be preferred for draining the whole, as the water is much more eaſily drawn through it, than through gravel, ſand, or marle; conſequently, by draining the ſpring there, the whole water which communicates therewith flows through it; water always preferring a ſtraight or clear to a crooked channel. But in ſtone beds, the trench ought to be made from ſix to eight yards from the tail of the bed, or the place where the rock ends; becauſe, in limeſtone, and in other rocks, the tail, as it is technically called, is harder than any other part of the rock, and there are few, if any, fiſſures in it; but by going a few yards

yards above, you get into a softer part of the bed, and the water is more accessible. The tail of these beds may often be found in a point or promontory, jutting out from the adjacent heights.

"4. The trench, in general, should be directed in a line with the bottom of the hill, because it makes the best separation between the Upland and the Meadow Inclosures, and the spring can best be intercepted. The trench, however, must be carried in the line of the spring, or near it; for if it diverges from it at any distance, all prospect of reaching the spring, by tapping it, or otherwise, is over, and the labour bestowed upon digging it, is probably lost.

"5. It is better to make a new trench than to tap the spring in any old brook or run of water, where that may be practicable; for though the spring, when once it bursts out, has force enough to throw up any stones, sand, &c. that may accidentally fall into it, yet brooks, in a flood, may bring down such immense quantities of sand, &c. as completely to overweigh and choak up the spring, and so much caution

is neceſſary to prevent any riſk of ſuch a circumſtance, that when the trench croſſes any runlet of water proceeding from a ſmall brook, or from a collection of ſurface water, the trench is puddled, ſo as not to receive it, leſt it ſhould blow up, and deſtroy the works.

"Laſtly, having fixed on the general line of direction, and marked out the trench, you are to begin at the bottom or loweſt level, carrying your trench gradually up, the ſpirit-level in this part of the operation being your guide. The fall for the water need not be very conſiderable; a few inches in a hundred yards will be ſufficient.

"In digging the trench, no tools but thoſe of the moſt common ſort are made uſe of, and common labourers can carry on the trench, under an experienced foreman or overſeer. The auger, which muſt often be made uſe of for tapping the ſpring, may be from one and a half to two inches diameter, and is applied in the ordinary manner. If, in boring, a ſtone is met with, the auger muſt be taken off, and a chiſſel

or punch ſcrewed on, to penetrate ſo hard a ſubſtance.

"Sometimes the ſpring is cut off by the trench alone; but in many caſes it lies greatly below the level of the trench, in which it is neceſſary to make uſe of the auger, for tapping the ſpring, as it is called. Mr. Elkington bored an auger-hole near Tamworth, thirty feet in depth, which threw water up equal to three hogſheads in a minute, and completely drained all the neighbourhood.

"To judge when to make uſe of the auger, is a difficult part of the buſineſs; and here it is to be obſerved, that if the water, from having a ſtraight and clear channel, riſes without difficulty through the hole made by the auger, it may draw off the ſpring above, and even drain all the neighbourhood, and you may proceed no farther. For natural ſprings often iſſue through narrow and crooked perforations, and, conſequently, the water may prefer the eaſier though lower orifice. If it is certain that all the water in the ſpring flows through the hole made by the auger, you may there ſtop; if not, the trench

muſt

muſt be carried farther, and the auger again made uſe of.

"The trench being once made, and the ſpring cut off, either by tapping or otherwiſe, it is then neceſſary to determine whether the drain ſhould be open or covered. If the drain can with propriety be made a fence at the ſame time, it had better be open, if not, it ought to be covered. No apprehenſion need to be entertained of the holes made by the auger being filled up, whether the drain is open or covered, unleſs other waters are admitted; becauſe ſuch is the force of the ſpring, that it will throw up any ſtones, earth, or other ſubſtances that might accidentally get into it, and it can be injured by nothing, but great quantities coming upon it at once.

"If the drain is to be covered, the mode adopted by Mr. Elkington is, to make it ſquare, either of common brick or ſtone. Of the two, ſtone, when flat, is preferable; at the ſame time, when ſtone cannot be had, a ſort of brick, invented, it is ſaid, by Mr. Elkington, anſwers the purpoſe well.

"But

"But the tax (which certainly ought to be taken off, on bricks for drains) prevents the general uſe of this article, though ſo well calculated for the purpoſe. If the drain is well made, it may laſt for ages; the force of the running-water preventing it from filling up, more than a ſpring flowing through the bowels of the earth, provided the mouth of the drain is kept open, and regularly cleaned out when neceſſary. None of thoſe made by Mr. Elkington have as yet failed; any perſon who makes in future, may ſafely engage to keep them in repair for fifty or one hundred years.

"This ſyſtem of draining land is ſometimes attended with extraordinary conſequences. By it, not only the land below the natural ſpring, or even above the artificial ſpring, is drained, but the waters from the neighbouring heights, finding a new and eaſier channel, abandon the places to which they formerly went, and thus a tract of country may be drained, without the leaſt apparent communication with the ſpring intended to be drained, or the trench made to it. Nay, a drain made on one ſide of a hill has been known to

make

make ſprings and wells on the other ſide quite dry, opening a channel of an eaſier ſort, to which the water naturally draws.

" As yet, Mr. Elkington has only made uſe of theſe diſcoveries for the purpoſe of draining the land. But as the complete command of an unexpected treaſure of water is thus obtained, it is probable, that the plan may be very much improved, by uſing the water thus obtained for the purpoſe of flooding land, which it is well known is the greateſt of all improvements, as it requires little pains or expence to inſure, by means of the water alone, luxuriant crops and perpetual fertility. From ſprings alſo ſuch quantities of water may be obtained, as may be of uſe in regard to mills and navigations, and in ſupplying private houſes, and even towns and villages, with wholeſome water to drink, or to uſe for other purpoſes, inſtead of mere puddle.

"Mr. Elkington being extremely ſucceſſful in judging of the ſtrata of the earth, where it has not been greatly altered by ſome convulſion of nature, it may be right to ſtate the principles on which he acts.

His

His mode of judging of the ſtrata is not from the herbage that grows upon the ſurface, which is often artificial, and not natural (ruſhes only excepted, which denote clay) nor, as ſome imagine, from the morning and evening vapour; but in wet weather he judges by the ſtate of the ſurface, the veins of clay being then wet, whereas thoſe of ſand are comparatively dry. The beſt mode of determining the matter is, however, by examining the neighbouring heights, particularly if any pits or quarries have been made in them, becauſe, if the one height at all reſembles the other, the ſtrata on the ſame level will probably be the ſame. He alſo judges, with remarkable preciſion, how to find ſtone in places where it would not be generally looked for, and to diſcover the place where wells may be made with the beſt chance of ſucceſs.—The rules on which he acts in regard to theſe two articles, muſt be the ſubject of future enquiry. The knowledge of the different ſtrata will be greatly facilitated by Mr. Elkington's giving plans of the ſtrata in England, ſo far as he has travelled through it; the

ſame ſtrata frequently running in a line from ſea to ſea.

"On the whole, it appears that this mode of draining land injured by ſubterraneous waters, is by far the moſt effectual of any that has yet been ſuggeſted; and, to the credit of Mr. Elkington, it is to be obſerved, that he made no difficulty in communicating the nature of his diſcoveries to the Committee of the Board of Agriculture, appointed for the purpoſe of meeting with him upon the ſubject; and that he left it entirely to the Board to make him any remuneration, or not, as they might judge proper.

"Mr. Elkington having thus enabled the Committee, to form ſome idea of his ſyſtem of draining, and the principles on which it is founded, it only remains to point out the beſt mode of making others maſters of the ſubject, ſo that the benefits thereof may be ſpread as quickly as poſſible over the kingdom. Mr. Elkington is of opinion, that the moſt likely plan for that purpoſe, is, for the Board either to pitch upon ſome intelligent perſons to travel about with him, to whom he will communicate

communicate his ideas, and explain the principles on which he acts more distinctly, by pointing out on each spot, respectively, the manner in which he would drain the different kinds of soil; or to bind apprentices to him, whom he would readily instruct. Perhaps, a tour over the whole island, would be adviseable, beginning with the Eastern, and returning by the Western coasts of the kingdom. Mr. Elkington would thus be enabled to judge, to what extent this mode of improvement could be carried, and whether the same system will answer amidst the hills and vallies of Wales, or Scotland, as in those of Lancashire, where he has already been so successful."

The only remark I shall make on the above is, that it is not easy to form an idea how such a performance could ever have been produced. Perhaps, it may be accounted for on the supposition that the following case could have happened.—If Mr. Elkington, when he met the Committee of the Board of Agriculture at Wooburn-

Abbey, for the purpoſe of explaining to them the principles of his mode of draining, ſhould have candidly told them, that he was merely a plain practical man, who was little acquainted with philoſophical principles of any ſort, and therefore was not able to give any kind of explanation ſuch as they ſeemed to require; that he could not clearly expreſs, perhaps, any of his ideas, ſo as to make them intelligible to gentlemen of their rank; but, if they would have the goodneſs to ſhow him a field that required to be drained, he would let them ſee in what manner he ſhould proceed, and give them the beſt explanation he could of every thing about which they ſhould interrogate him as he went on; and that this was the only way in which he thought he could make the reaſons of his practice be fully underſtood. Should this, I ſay, have happened, and ſhould this have been all the information the Committee could obtain from himſelf; and ſhould they farther think, that after what had happened, it would be abſolutely neceſſary for the Committee to make ſome *report* to the Board; and ſhould

they thus circumſtanced, have charged ſome perſon to make out the beſt account *he could* on this ſubject; and ſhould that perſon, who had formed a few vague notions from the imperfect hints of Mr. Elkington ill underſtood, and mingled with former ideas adopted at ſchool, make out that account; ſuch a production as that which has been above exhibited, might naturally enough have been the reſult.— I do not ſay, that this did actually happen; but, I think, it would be difficult to account for ſuch a performance in any other way. It certainly never could have been written by one who had even *attempted* to put his own directions into practice.

In the preſent edition ſome additions have been made to this Eſſay, to render it ſomewhat more complete than before; but theſe additions are carefully diſtinguiſhed from the original performance. Theſe additions, with ſome others, are printed ſeparately, to be ſold for the accommodation of the purchaſers of the former editions of this work: and for the ſake of other purchaſers, who may incline to have the Eſſay on Draining complete, that Eſſay

has been there given entire. To which is added, the Two Letters to Sir John Sinclair, illuſtrative of that ſubject.

It is hoped, the author will be pardoned for employing the ſame plates for the ſeparate publication as for the book, though they contain ſome objects that do not relate to the preſent Eſſay.

ON

DRAINING BOGS

AND

SWAMPY GROUNDS.

IN the preceding Eſſay, I have ſhowed, that water may on ſome occaſions be of great utility to the farmer; yet, as there are few things more prejudicial to him than a ſuperabundance of it, when too long continued upon the ground, it behoves him to guard againſt this evil as much as he poſſibly can; and at almoſt any expence, to free his ground from it, if he hopes to make any conſiderable improvement thereon; for, unleſs this be firſt done, all his other operations will turn out to little account.

The methods of drawing off ſtagnant water, which may be accumulated in any low ſituation, for want of a proper outlet, are in general ſo obvious to every man of diſcernment, who examines the ſituation of the ground, that I ſhall not tire the

reader by enlarging upon that head; but shall proceed immediately to treat of the most proper method that I have experienced, of draining such ground as is hurt by springs oozing out upon them (usually distinguished by the name of *wet*, or *spouting* ground) and bogs*; as this is a matter of much greater difficulty than the former, and the principles upon which it should be conducted, far less generally understood.

Springs are formed in the bowels of the earth, by water percolating through the upper strata, where they are of a porous texture, which continues to descend downwards, till it meets with a stratum of clay that intercepts it in its course; where, being collected in considerable quantities, it is forced to seek a passage through the porous strata of sand, gravel, or rock, that may be above the clay, following the course of these strata till they approach

* It will appear to the reader, that the term *bog*, is here employed in its most unlimited acceptation, denoting any kind of quaggy ground arising from too much moisture; and not according to the usual meaning of the word in Ireland, where it, for the most part, only denotes what is in Scotland called peat-moss.

the ſurface of the earth, or are interrupted by any obſtacle which occaſions the water to riſe upwards, forming ſprings, bogs, and the other phænomena of this nature; which being variouſly diverſified in different circumſtances, produce that variety of appearances in this reſpect that we often meet with.

This being the caſe, we may naturally conclude, that an abundant ſpring need never be expected in any country that is covered to a great depth with ſand, without any ſtratum of clay to force it upwards, as is the caſe in the ſandy deſerts of Arabia, and the immeaſurable plains of Lybia. Neither are we to expect abundant ſprings in any ſoil that conſiſts of an uniform bed of clay from the ſurface to a great depth: For, it muſt always be in ſome porous ſtratum that the water flows in abundance, and it can be made to flow horizontally in that only, when it is ſupported by a ſtratum of clay, or other ſubſtance that is equally impermeable by water. Hence the *rationale* of that rule ſo univerſally eſtabliſhed in digging for wells, that if you begin with ſand or gra-

vel, &c. you need ſeldom hope to find water, till you come to clay; and if you begin with clay, you can hope for no water in abundance, till you meet with ſand, gravel, or rock.

It is neceſſary that the farmer ſhould attend to this proceſs of nature with care, as his ſucceſs in draining bogs, and every ſpecies of damp and ſpouting ground, will in a great meaſure depend upon his thorough knowledge of this,—his acuteneſs in perceiving in every caſe, the variations that may be occaſioned by particular circumſtances, and his ſkill in varying the plan of his operations according to theſe. As the variety of caſes that may occur in this reſpect, is very great, it would be a tedious taſk to enumerate the whole, and deſcribe the particular method of treating each; I ſhall, therefore, content myſelf with enumerating a few particular caſes, to ſhew in what manner the principles above eſtabliſhed may be applied to practice.

Let Fig. 21ſt repreſent a perpendicular ſection of a part of the earth, in which AB is the ſurface of the ground, beneath which

which are ſeveral ſtrata of porous ſubſtances, which allow the water to ſink through them till it reaches the line CD, that is ſuppoſed to repreſent the upper ſurface of a ſolid bed of clay; above which lies a ſtratum of rock, ſand, or gravel. In this caſe it is plain, that when the water reaches the bed of clay, and can ſink no farther, it muſt be there accumulated into a body; and, ſeeking for itſelf a paſſage, it will flow along the ſurface of the clay, among the ſand or gravel, from D towards C, till at laſt it iſſues forth at the opening A, a ſpring of pure water.

If the quantity of water that is accumulated between D and C is not very conſiderable, and the ſtratum of clay approaches near the ſurface, in that caſe, the whole of it will iſſue by the opening at A, and the ground will remain dry, both above and below it. But if the quantity of water is ſo great, as to raiſe it to a conſiderable height in the bed of ſand or gravel, and if that ſtratum of ſand is not diſcontinued before it reaches the ſurface of the ground, the water in this caſe, would not iſſue at A only, but would like-

wiſe ooze out in ſmall ſtreams through every part of the ground, between A and a; forming a barren patch of wet ſandy or gravelly ground upon the ſide of a declivity: Which is a phænomenon that every attentive obſerver muſt have frequently met with.

To drain a piece of ground in this ſituation, is perhaps, the moſt unprofitable taſk that a farmer can engage in; not only becauſe it is difficult to execute, but alſo, becauſe the ſoil that is gained is but of very little value. However, it is lucky that patches of this kind, are ſeldom of great breadth, although they ſometimes run along the ſide of a declivity, in a horizontal direction, for a great length.

The only effectual method of draining this kind of ground, is, to open a ditch, as high up as the higheſt of the ſprings at a, which ſhould be of ſuch a depth as not only to penetrate through the whole bed of ſand or gravel, but alſo to ſink ſo far into the bed of clay below, as to make a canal therein, ſufficiently large to contain and carry off the whole water. Such a ditch is repreſented by the doted lines a,

e, *z*; but as the expence of making a ditch of such a depth as this would suppose, and of keeping it afterwards in repair, is very great; it is but in very few cases that this mode of draining would be adviseable, and never, unless where the declivity happens to be so small, that a great surface is lost for little depth; as would have happened here, if the surface had extended in the direction of the doted line *a d*.

But, supposing that the stratum of clay, after approaching to the surface at A, continued to keep at a little depth below ground; and that the soil which lay above it was of a sandy or spungy nature, so as to allow the water to penetrate it easily; In that case, even supposing the quantity of water that flowed from D to C, was but very inconsiderable, instead of rising out at the spring A, it would flow forward along the surface of the clay, among the porous earth that forms the soil, so as to keep it constantly drenched with water, and, of consequence, render it of very little value.

Wetness, arising from this cause, is usually

usually of much greater extent than the former; and as it admits of an easy cure, it ought not to be one moment delayed. For a ditch of a moderate depth opened at A, and carried through a part of the stratum of clay (as represented by the doted lines A, *k*, *f*) would intercept and carry off the whole of the water, and render the field as dry as could be desired. It is, therefore, of very great consequence to the farmer, accurately to distinguish between these two cases, so nearly allied to each other in appearance; and as this can be easiest done by boring, every one who has much ground of this kind, ought to provide himself with a set of boring-irons, which he will likewise find use for on other occasions.

I might here enumerate a great variety of cases which might be reduced to the same head with the foregoing: but as any attentive reader may, after what has been said, be able easily to distinguish these, I shall only in general observe, That every soil of a soft and porous texture, that lies upon a bed of hard clay, whatever its situation in other respects may be, will in

some

ſome meaſure be ſubjected to this diſeaſe: And if it is upon a declivity of any conſiderable length, the undermoſt parts of the field will be much damaged by it, unleſs ditches are thrown up acroſs the declivity, at proper diſtances from one another, to intercept the water in its deſent.

It may not likewiſe be improper here to remark, that, in caſes of this nature, unleſs where the ſoil is of a very great depth, the malady will always be encreaſed, by raiſing the ridges to a conſiderable height; as will appear evident by examining Fig. 22, in which the line AB repreſents the ſurface of a field of this nature, and CD the ſurface of the bed of clay. Now, if this field were raiſed into high ridges, as at F, F, F, ſo as that the furrows E, E, E, deſcended below the ſurface of the clay, it is plain, that all the water that ſhould ſink through the middle of the ridge, would run along the ſurface of the clay, till it came to the ſides of the ridge L, L, L, L, L, L, which would thus be kept continually ſoaked with water; whereas, if the ground had been kept le-

vel, as in the part of the field from G to H, with open furrows H, at moderate diſtances from one another, the water would immediately ſink to the clay, and be carried off by the furrows, ſo as to damage the ſoil far leſs, than when the ridges are high.

If the ſoil is ſo thin, that the plough can always touch the clay, the ridges ought to be made narrow and quite flat, as from G to H; but if there is a little greater depth of ſoil, then it ought to be raiſed into ridges of a moderate height, as from H to K, ſo as to allow the bottom of the furrow to reach the clay. But neither is this neceſſary, where the ſoil is of any conſiderable depth.

I have ſeen ſome induſtrious farmers, who having ground in this ſituation, have been at the very great expence of making a covered drain in each furrow. But, had they rightly underſtood the nature of the diſeaſe, they never would have thought of appling ſuch a remedy; as muſt appear evident at firſt ſight to thoſe who examine the figure. The ſucceſs was, what

what might be expected from ſuch a fooliſh undertaking.

Theſe obſervations, it is to hoped, will ſuffice as to the manner of treating wet, ſandy, or porous ſoils. I now proceed to take notice of ſuch as are of a ſtiff clayey nature, which are often very different in appearance, and require a different treatment from theſe.

Suppoſe that (as in Fig. 23) the ſtratum of ſand or gravel, D C, ſhould be diſcontinued, as at E, and that the ſtratum above it ſhould be of a coherent clayey nature: In this caſe, the water that flowed towards E, being there pent in on every ſide, and being accumulated there in great quantities, it muſt, at length, force a paſſage for itſelf in ſome way; and preſſing ſtrongly upon the upper ſurface, if any one part is weaker than the reſt, it there would burſt forth, and form a ſpring (as, ſuppoſe, at A). But if the texture of every part of this ſtratum were equally ſtrong, the water would ſqueeze through many ſmall crannies, and would ooze out in numberleſs places, as between A and F, ſo as to occaſion that kind of wetneſs

which

which is known by the name of a ſpouting clayey ſoil.

The cure, in this caſe, is much more eaſily effected than in any of the former: For, if a ditch of a conſiderable ſize be opened, as at A, towards the lowermoſt ſide of the ſpouting ground, ſo deep as to penetrate through the upper ſtratum of clay, and reach to the gravel, the water will riſe up through it, at firſt, with very great violence, which will gradually decreaſe, as the preſſure from the water behind is diminiſhed. And when the whole of the water accumulated in this ſubterraneous reſervoir is run off, there being no longer any preſſure upon the clay above it, the whole ſoon becomes as dry as could be deſired; and continues ſo ever afterwards, if the ditch be always kept open. This I ſpeak from experience, I having rendered ſome fields of this kind that were very wet, quite dry, by this method of treating them.

It will hardly be neceſſary for me here to put the farmer upon his guard, to be particularly careful in his obſervations,

that he may diſtinguiſh between the wetneſs that is produced from this cauſe, and that which proceeds from the cauſe before mentioned: Becauſe the treatment that would cure the one, would be of no uſe at all to the other.

The attentive obſerver, likewiſe, will readily perceive, that if any field that is wet from this cauſe, admits of being ploughed, it will be in equal danger of being hurt by being raiſed in high ridges, with the other kind of damp ground before mentioned: For, as the depth of earth above the reſervoir would be ſmaller in the deep furrows than any where elſe, there would, of conſequence, be leſs reſiſtance to the water in that place, ſo that it would riſe there in greater abundance. And if, in this caſe, a farmer ſhould dig a drain in each furrow;—as a conſiderable quantity of water would riſe into them, in ſome caſes, the ground might be improved, or even quite drained thereby, (eſpecially if they ſhould have accidentally reached the gravel in any other place,) although at an expence much greater

than

than was neceſſary *. I take notice of this circumſtance, in ſome meaſure, to prevent the prejudice that ſome inattentive obſervers might entertain againſt what we ſaid before of this method of draining, from their having accidentally ſeen ſome fields that may have been bettered by it.

Bogs are only a variety of this laſt-mentioned kind of wet ground, and therefore ought, in general, to be drained after the ſame manner with them. Clay is a ſubſtance that ſtrongly reſiſts the entrance of water into it; but, when clay is long drenched with water, it is, in proceſs of time, in ſome meaſure, diſſolved thereby, loſes its original firmneſs of texture and conſiſtence, and becomes a ſort of ſemi-fluid maſs, which is called a bog. And as theſe bogs are ſometimes covered with a ſurface of a particular kind of graſs, with very matted roots, which is ſtrong enough

* This ſeems to have been preciſely the caſe, in the firſt attempt of Mr. Elkington at draining, in which caſe he *accidentally* penetrated the bed of clay, and reached the pervious ſtratum below it.

to

to bear a ſmall weight without breaking, although it yields very much, it is, in theſe circumſtances, called a *Swaggle.*

But whatever be the nature of the bog, it is invariably occaſioned by water being forced up through a bed of clay, as juſt now deſcribed, and diſſolving, or ſoftening, if you will, a part thereof. I ſay only a part, becauſe, whatever may be the depth of the bog, or ſwaggle, it generally has a partition of ſolid clay between the bog and the reſervoir of water under it, from whence it originally proceeds: For, were not this the caſe, and were the quantity of water conſiderable, it would meet with no ſufficient reſiſtance from the bog, and would iſſue through it with violence, and carry the whole ſemifluid maſs along with it. But this would more inevitably be the caſe, if there was at firſt a cruſt at the bottom of the bog, and if that cruſt ſhould ever be broken; eſpecially, if the quantity of water under it were very conſiderable. And as it is probable, that in many caſes of this ſort, the water ſlowly dilutes more and more of this under-cruſt, I make no doubt but that in the revolution of many ages, a

great many irruptions of this kind may have happened; although they may not have been deemed of importance enough to have the hiſtory of them tranſmitted to poſterity *.

Of this kind, although formed of a different ſubſtance, I conſider the flow of the Solway moſs, in Cumberland, to have been; which, upon the 16th November, 1771, burſt its former boundaries, and poured forth a prodigious ſtream of ſemifluid matter, which, in a ſhort time, covered ſeveral hundred acres of very fine arable ground. Nor will any one who is acquainted with the nature of moſs, who knows its reſemblance to clay in its quality of abſorbing and retaining water, and its very eaſy diffuſibility therein, be ſurpriſed at this; as, from all theſe properties, it is much better adapted for forming an extenſive bog, and therefore in greater danger of producing an extenſive devaſtation, by an eruption of the water into it,

* Probably, the eruption which produced Saint Winnifred's well, in North Wales, may have been of this ſort. *Note to the fourth Edition.*

than

than thoſe that are formed of any kind of clay whatever *.

If the bog or ſwampy ground be upon a declivity, the ditch ought to be carried acroſs the field, about the place where the loweſt ſprings ariſe. But if the ſurface of the ground be level, or nearly ſo, as between A and B (Fig. 24) and the ſprings break out in ſeveral places, *q q q q q q*, ſo as to form ſoft quagmires interſperſed through the whole of the field, it will be of

* Since the above was written, I find the eruption of Solway-moſs was produced in a manner very different from the above. The water which carried it off, inſinuated itſelf between the ſmooth bed of clay, below the moſs, in ſuch great quantities, as, without ſoftening the moſs ſo as to reduce it to the ſtate of a ſemi-fluid maſs, heaved it up, ſo as to be as if afloat upon the water, which ſhoved it bodily forward with the current, till it was left, in a great meaſure, in its natural ſtate, lying above the corn-fields, to the whole depth of the moſs. For farther elucidations on the ſubject of moſs, ſee a Practical Eſſay on Peat Moſs. Robinſons, 1794.—

N.B. At the time the preſent Eſſay was written, I had formed no diſtinct idea of the nature of moſs; and at the time the Eſſay on moſs was written, I knew nothing of the fact here ſtated. It affords an additional proof of the truth of the hypotheſis there brought forward. *Note to the fourth Edition.*

little confequence in what part the drain is opened; for, if it be dug fo deep as to allow the water to rife in it with freedom, it will iffue through that opening, and the field will be left perfectly dry.

But as it may frequently happen that the ftratum of gravel fhall be at a confiderable depth beneath the furface of the earth, and as it may be fometimes even below the level of the place into which the drain muft be emptied, it might fometimes be extremely difficult to make a ditch fo deep as to reach the bed of fand or gravel. But it is lucky for us that this is not abfolutely neceffary in the prefent cafe; becaufe a drain, of two or three feet deep, as at D, will be equally effectual with one that fhould go to the gravel. All that is neceffary in this cafe is, to fink pits (P) in the courfe of the drain, at a moderate diftance from one another, which go fo deep as to reach the gravel. For, as the water there meets with no refiftance, it readily flows out at thefe openings, and is carried off by the drain, without being forced up through the earth; fo that the ground is left entirely dry ever after.

I have

I have likewiſe drained ſeveral fields in this way; and as I have generally found the appearances pretty much alike, I ſhall, for the information of the inexperienced reader give a ſhort account of them:

If you attempt to make your pit in one of theſe ſoft quaggy places, where the water is found in great abundance, you will meet with very great difficulty in forming it: For, as the ſubſtance of which it is compoſed is a ſemi-fluid, it will always flow into the hole as faſt as you dig it. On this account, I would adviſe, not to attempt to make the pit in the ſwaggle, but as near it in the ſolid earth as you conveniently can. However, if it be pretty firm, and of no great extent, it will be ſometimes practicable to make a pit in the ſoft bog, at the drieſt time of the year. This I have ſometimes practiſed, which gave me an opportunity of obſerving the nature of theſe bogs more perfectly than I otherwiſe would have had.

In the trials of this kind that I have made, the ſoft quaggy ground has ſeldom been above three or four feet deep, below which I have always found a ſtratum of

hard tough clay, uſually mixed with ſtones, and ſo firm that nothing but a mattock or pick-axe could penetrate it: And as this ſtratum is comparatively much drier than the ground above it, an inexperienced operator will be very apt to imagine that it is the bottom he is in ſearch of.

In digging through this ſtratum, you will frequently meet with ſmall ſprings oozing out in all directions; ſome of them that might fill the tube of a ſmall quill, and others ſo ſmall as to be ſcarcely perceptible. But, without regarding theſe, you muſt continue to dig on without intermiſſion, till you come to the main body of the reſervoir, if I may ſo call it, that is contained in the rock, gravel, or ſand; which I have generally found from two to four feet below the bottom of the ſwaggle, and which you will be in no danger of miſtaking when you come to it. For, if there has been no opening made before that time in the field, as ſoon as you break the cruſt immediately above the gravel or rock, the water will burſt forth like a torrent, and, on ſome occaſions, will riſe like

like a *jet d'eau*, to a conſiderable height above the bottom of the ditch; and continue to flow off with great impetuoſity for ſome time, till the pent-up water being drained off, the violent boiling up will begin to ſubſide, and the ſtrength of the current to abate, and in a ſhort time it will flow gently out like any ordinary ſpring.

Allowing it to remain in this ſtate for ſome time, the quaggy earth will ſoon begin to ſubſide, and gradually become firmer and firmer every day; ſo that in the ſpace of a few months, thoſe bogs that were formerly ſo ſoft, as hardly to ſupport the weight of a ſmall dog, will become ſo firm, that oxen and horſes may tread upon them without any danger of ſinking, at the very wetteſt ſeaſon of the year.

I had a field of this nature, that, by having only one ſuch pit, as I have now deſcribed, opened in it, was entirely drained, to the diſtance of above a hundred yards around in every direction.

But, as it is poſſible that the ſtratum in which the water runs, may be in ſome places

interrupted, it will be in general expedient to make ſeveral of theſe pits, if the field is of great extent; always carrying the drain forward through the lowermoſt part of the field, or as near the quag as you conveniently can; and ſinking a pit whereever you may judge it will be moſt neceſſary. But if the ſtratum of gravel is not interrupted, there will be no violent burſt of water, at opening any of theſe after the firſt, as I have frequently experienced.

To keep theſe wells from cloſing up, it is always expedient to fill them up with ſmall ſtones immediately after they are made, which ought to riſe to the height of the bottom of the drain.

I have often imagined, that the expence of digging theſe pits might be ſaved, by boring a hole through this ſolid ſtratum of clay, with a large wimble (auger) made on purpoſe; but as I never experienced this, I cannot ſay whether or not it would anſwer the deſired end exactly.

If the whole field that is to be drained, conſiſts of one extenſive bog, it will require a long time before the whole work can be entirely finiſhed; as it will be im-

poſſible to open a drain through it, till one part of it be firſt drained, and becomes ſolid ground. In a ſituation of this kind, the undertaker, after having opened a drain to convey the water from the loweſt part of the bog, muſt approach as near to the ſwampy ground as he can, and there make his firſt pit, which will drain off the water from the neareſt parts of the bog.

When this has continued open for ſome time, and that part of the bog is become ſo ſolid as to admit of being worked, let him continue the ditch as far forward through it as the ſituation it is in will admit of, and there ſink another pit; and proceed gradually forward in the ſame manner, making croſs cuts where neceſſary, till the whole be finiſhed.

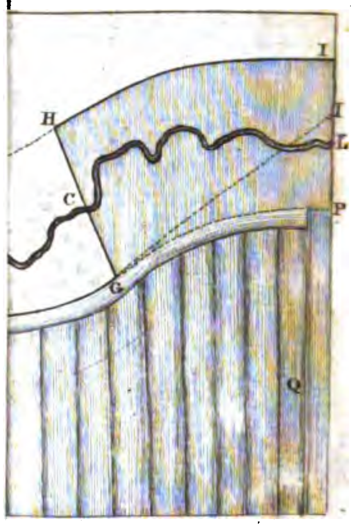
In this manner, may any bog or tract of ſpouting ground, of this nature, be rendered dry, at a very inconſiderable expence. And as there can be no other method of draining ground of this ſort effectually, I recommend the ſtudy of it to the attention of every diligent farmer who may have occaſion for it. Let him firſt be extreme-

ly

tions of a warm imagination, I ſhall content myſelf with having pointed out this evil to thoſe who may have it in their power to examine into the cauſes of this particular malady, and to point out to others the eaſieſt and moſt efficacious cure.

Here ends the Eſſay, as it was originally printed.


Fig. 19.
B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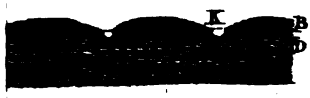
K
B
D


Fig. 24.
D
B
P

ADDITIONS

TO THE

ESSAY ON DRAINING,

MADE IN THE YEAR 1797.

I AM no longer reſtrained by the conſiderations which influenced me when this Eſſay was firſt publiſhed; an experience of more than twenty years farther has removed thoſe ſcruples entirely: And though the attentive reader will find little in what follows that may not be inferred from what has gone before, yet it will not perhaps prove diſagreeable, to ſee how the few ſimple principles above ſuccinctly developed, may be eaſily applied in ſome practical caſes which aſſume a conſiderable diverſity of appearance.

The peculiar ſpecies of wet land, that has been juſt now deſcribed, is not in general occaſioned by ſprings; for in the kind of ſoil here deſcribed, ſprings, properly ſo called, are rarely to be found;—it originates, for the moſt part, entirely from water that falls from the clouds. When rain falls in

abundance

abundance upon a field of the kind here deſcribed, a part of the water will find its way along the ſurface towards the furrows, if any ſuch have been made in it, by which it will be carried off the field; but a conſiderable quantity of water will be abſorbed by the porous ſoil on the top, through which it will gradually ſink, till it reaches the ſolid bed of clay below, which, having never been opened up effectually, reſiſts the water, which can there penetrate downwards no farther. In that caſe, it can find no outlet until it forces its way laterally towards the furrows, ſlowly through the ſuperficial mould—or, if no furrows are provided to carry it off, it muſt remain as in a baſon, in which the ſuperficial ſoil is mixed with the water, ſo as to become a thin paſte, that muſt remain of a ſoft conſiſtency during wet weather, and which, when much rain hath fallen, will be only a ſmall degree removed from fluidity—While in this ſtate, it muſt be highly prejudicial to the vegetation of all thoſe plants we are in the uſe of cultivating in this country: But in this ſtate the ſoil muſt remain, drenched with water, until the return of dry weather. The ſun will then

evaporate

evaporate it; when the ſoaked paſte, now deprived of its moiſture, will aſſume a hard irony conſiſtence, which is equally unfit for the ſuſtenance of plants as it was in its moiſtened ſtate.

Such being the cauſes of this diſeaſe, the conſequences may be eaſily removed. The opening up of hollow drains, running diagonally acroſs the ſlope, at a ſmall diſtance from each other, if they can be kept open, will anſwer the ſame purpoſe, nearly, that the drawing of open water furrows in the ſame direction would have done, and will, doubtleſs, mitigate the evil, in proportion to their nearneſs to each other: but they muſt be very cloſe together indeed, if they remove it entirely—for ſtill the ſoil muſt be drenched in the manner before deſcribed, by the water forcing its way through it, until it reaches the drain.

But, as the rain-water will ſink perpendicularly through the ſoil, until it meets with the ſolid clay, before it attempts to ſeek a lateral direction, it muſt follow that that part of the mould which is neareſt to the clay, will be more drenched with water than thoſe parts of it which lie at a greater

greater diſtance above the clay; of courſe, the deeper the ſoil, the leſs will the ſurface-mould be liable to be drenched with hurtful moiſture.—Hence it follows, that if the ſoil ſhall be deepened to ſuch a degree, as that the water, even during the greateſt rains, ſhall not be forced to riſe ſo high as to chill the roots of the plants which grow upon it, the remedy wiſhed for will be effected.

Nor will this be a matter of ſuch great difficulty, as at firſt ſight it might appear—for as the rain ſinks ſlowly downward through ſuch a ſoil, that portion of rain which falls firſt continuing to ſink regularly, if the ſoil be mellow, without ſtopping, goes gradually downward, making way for that which follows, without being regorged back upon it till it meets the bottom—Hence, if we ſhould ſuppoſe, for the ſake of illuſtration, that the rain ſunk four inches downward in twenty-four hours, and that the rain continued without intermiſſion for three days together, the water would have penetrated, by that time, to the depth of twelve inches, had it met with no interruption before the rain abated; but

if

if the ſoil were no more than four inches deep, the water would have reached the bottom, in twenty-four hours, after which time, it could go no farther—but the rain continuing to pour on more, the ſoil towards the bottom, by acquiring freſh additions of water every moment, is there ſoon reduced to the ſtate of a ſemi-fluid paſte; and as the water muſt riſe higher and higher, while the rain continues, more of the ſoil muſt be drenched by it, until the whole ſoil becomes like a ſoft pap, that is incapable to ſupport the ſmalleſt animal. Or, if the open furrows or under-drains be near at hand, a part of the water will at laſt fall into theſe, and be carried off the field, after having waſhed the ſurface-mould in its paſſage ſo as thus to carry off with it all the ſoluble parts of the manures it has met with in its courſe. But if the penetrable mould had extended to a greater depth (ſay ſixteen or twenty inches) the water would not ſtop even when the rain abated, but continue to ſink farther, till at laſt it would be all imbibed by the earth, without having reduced any part of it to the ſtate of a pap—and even without the aid of any drain

whatever. Thus would the mould, having never been reduced to the ſtate of a paſte, continue friable, even when dry weather approached: and as the roots of plants growing upon the ſoil would thus be invited to ſtretch to a great depth, they would there find moiſture ſufficient to ſuſtain them, at a time when, if they had been forced to ſpread abroad near the ſurface, for want of depth of ſoil, they muſt have periſhed from lack of moiſture. In this way, the ſoil is rendered dry in moiſt weather, and moiſt in dry ſeaſons, to a degree that could not otherwiſe have been experienced. And, as it has been already ſaid, the water in its progreſs diſſolves and carries along with it, a portion of the vegetable manures, this portion of manure, by the proceſs now deſcribed, is all left in the ſoil, and of courſe tends to meliorate it, inſtead of being carried off from it either by the water-furrows or the drains, which becomes indiſpenſably neceſſary, where the ſoil is thin—and which unavoidably reduces it into that poor hungry ſtate ſo frequently experienced under circumſtances of the ſort here deſcribed.

There are found in many counties of

Great Britain, immenſe tracts of poor, hungry, clayey ſoils, that are all reducible to the claſs of which we now treat.—They have been denominated *hungry*, from the ſudden diſappearance of the effects of manures that have been laid upon them; they are alſo called *hide-bound*, becauſe of the hard ſtiffneſs, and miſerable appearance of the ſurface. Few ſoils are, in their preſent ſtate, more unprofitable than thoſe. Yet there are, perhaps, none, which, under a judicious management, could be rendered more productive than many of them. It often happens, that over the whole ſurface of ſuch ſoils, a thin crop of weakly ruſhes are produced, while it is allowed to remain in graſs; and fog or moſs, which eſtabliſhes itſelf there during the winter months, is almoſt the only vegetable production, that gives a ſickly verdure to the ſurface. Upon examination, it will be found, that in all caſes of this ſort, the unlooſened clay riſes very near to the ſurface; in conſequence of which, the ſuperficial mould, which has been ſtirred by the plough, to a ſmall depth only, being thinly ſpread over it, is ſubject to be drenched

through its whole depth by every violent rain, the manures completely waſhed out of it, and the whole reduced to a pappy paſte, that becomes hard like iron, when the ſummer heat diſſipates the moiſture. Under theſe circumſtances, whatever manures or culture are beſtowed upon it, are in a great meaſure, thrown away, as they are ſeen to produce but very little effect; and theſe ſoils, are therefore, in a great meaſure, abandoned as hopeleſs.

Many ſoils of this deſcription, however, if opened to a ſufficient depth, may be gradually brought into a ſtate of great productiveneſs. Indeed, many of the moſt productive diſtricts in this kingdom conſiſt preciſely of ſoils that were originally of this kind. When ſuch ſoils are thus opened up, they are, for the reaſons above aſſigned, more effectually drained than they could be by any other proceſs. The manures that are, after this is done, worked into the ſoil, are never carried off from it, but gradually tend to meliorate, and thus to render more tender and friable, the bottom ſoil; ſo as, in time, to become deep, ſound, and wholeſome land, which is

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neither ſtrongly affected by the viciſſitudes of drought nor of rain.

Theſe effects, however, are not to be expected to be felt at firſt, to their full extent. Some clays are ſo cohefive, that mere digging alone will not render them as permeable by water, as could be wiſhed. Before they can become ſufficiently friable for the purpoſe, to the higheſt degree that could be wiſhed, manures muſt have had time to operate upon them. For this reaſon, although the effect of deep digging, and copious manuring, will be at once ſenſibly felt, yet the melioration that will reſult from this proceſs, will be going forward for many years to come; and, by degrees, it will be coming nearer and nearer to that higheſt degree of productiveneſs for which the old lands of that deſcription, above named, are ſo very remarkable.

We have an opportunity of obſerving the effect of thus opening the ſoil to a great depth, in our gardens, which, in conſequence of being univerſally trenched over, as an initiatory ſtep, are found to continue healthfully dry, even in ſoils of

this kind, without the aid of either water-furrows, to carry off the ſurface-rain, or hollow-drains, to carry off the moiſture from below. If there be but one drain leading from the loweſt part, to allow the little water that *ſeeps** down to it, to be carried freely away, that is quite enough to preſerve the mould healthfully dry. But in fields where the plough can penetrate to a much ſmaller depth, it is found univerſally, that many water-furrows are abſolutely required, before ſuch a ſoil can be prevented from ſuſtaining great damage from the paſting proceſs above deſcribed; and that hollow-drains are likewiſe required to aid them, before the ground can be made tolerably healthful.

I may be permitted to obſerve, however, that in moſt caſes of this ſort, where the ſurface-mould is no deeper than the plough goes, hollow-draining becomes neceſſary only in conſequence of the ridges being laid in an improper direction; for, when the furrows lie directly up and down

* Is *ſeeps* an Engliſh word? It means to flow gradually, and in very ſmall quantities through ſome reſiſting medium.

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the declivity, it is eaſy to obſerve, that whatever water ſinks through the mould, will have a tendency, when it reaches the clay, to run forward among the ſoil towards the bottom of the hill, rather than to force a paſſage for itſelf laterally towards the furrows.—In conſequence of this, the ſoil, eſpecially towards the middle of the ridge, in particular where the declivity is conſiderable, will be drenched with water nearly as much as if no water-furrows were left in the field. To intercept that water therefore, in its deſcent, hollow-drains, that run aſlant the ridges, become abſolutely neceſſary.—If the furrows had been laid in the ſame direction with the drains, nearly the ſame benefit would have reſulted from the furrows as the drains afford. And were it not for the inconvenience that is felt in ploughing in that direction, theſe furrows would even operate more efficaciouſly, in moſt caſes, in drying the ground, than the drains. For, it muſt be obſerved, that in making hollow-drains, it becomes neceſſary that they ſhould not be ſo far filled with bruſh-wood, or other porous matter,

through which the water can be permitted to ſink eaſily, as to reach the plough-furrow; otherwiſe that matter would be deranged by its operations, and in ſuch ſtiff mould, the earth that is put above the bruſh-wood is apt to cake, and become ſolid, ſo as to reſiſt the entrance of water into the drain. This is a very ſerious evil, which every perſon who has land in that ſituation, muſt have often experienced. Open furrows are entirely freed from all danger of this ſort. Where dry peat-droſs can be obtained in abundance, for filling the drains at top, this inconvenience would be obviated. See Treatiſe on Peat Moſs.

But, although the facts above ſtated ſufficiently evince, that the looſening the ſurface mould to a ſufficient depth, in a ſoil of the nature here treated, will, in moſt caſes, prevent the neceſſity of under-draining of any ſort, and in *all* caſes will effect a great and radical improvement;—yet I wiſh not to be underſtood to ſay, that under-draining will not prove, in ſome caſes, uſeful. But even in thoſe caſes where they may prove uſeful, the number

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of drains wanted, will be prodigioufly diminifhed. If the procefs above recommended be adopted, one drain will, under thefe circumftances, do more good than a hundred would do without it—(indeed, no number of drains whatever could fo effectually meliorate the foil) and, it deferves to be remarked, that where fuch a drain fhall be made, the evil juft ftated may be entirely obviated; for as the plough never reaches near to the bottom of the mould, the hollow-drain may be filled quite to the top of the clay, or even above it, with porous matter, without any rifk of its being deranged, and it will, of courfe, keep always open, to receive any water that may have occafion to fall into it.

As to the moft advifeable mode of deepening the foil, many confiderations require to be adverted to, before that can be determined. In general, the furface-mould is more mellow than any of the bottom foil, on which account, it ought not to be buried by trenching it down; the effects of which, upon a very ftiff clay, where manures are not extremely abundant,

dant, can very slowly be overcome. In such cases, it will be more adviseable, after having turned over a large and deep furrow of the surface-mould, to make men follow, in the same furrow, with spades, and dig it over, without turning it upon the top; or loosen it to a considerable depth, with an implement which may be called a *crow-spade* (being a small iron crow, sharpened at the point, into the form of a very narrow-pointed spade, not exceeding three inches at the broadest part) having a foot-piece projecting from the stalk, and a cross handle of wood at top, which I have found to be a strong handy tool for works of that kind. Where the soil is perfectly free from stones, a kind of plough, having a share and cutters only, for loosening without turning over the soil, may be made to follow the other plough, in the same furrow, an implement which has been lately introduced into Lancashire, under the name of the *miner*. This kind of under-mould loosening ought to be repeated from time to time, when it is perceived to get bound below; but the surface-mould should always be preserved

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at top. In moſt caſes, where circumſtances permit of it, the friability, dryneſs, and productiveneſs of ſuch a ſoil will be greatly promoted by a *copious* admixture of lime or other calcareous matter with it. The *quantity* can ſcarcely be too great; but on ſuch ſoils a dreſſing of a chaldron or two of lime per acre, will be ſo diſproportionately ſmall, as to produce ſcarcely any ſenſible effect. In every caſe, ſoils of this nature admit of, and in their poor ſtate require, a more abundant manuring than any others. After they have been thus enriched and meliorated by time, they will produce greater crops than any other ſoil, even with a moderate quantity of manures.

It would be foreign from the ſcope of this Eſſay to enter more fully into the proper mode of managing ſuch ſoils, or of peculiariſing with great nicety the diverſity of ſoils that all belong to this general claſs. Theſe diverſities are very great, and ſome kinds will repay the expence much ſooner than others. It is the proper buſineſs of the huſbandman to diſtinguiſh theſe; it only belongs to me here to

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ſay, that *all* of them will be greatly benefitted by the proceſs recommended. Neither muſt I here ſtop to explain in greater detail the moſt economical ways in which the ſoil may be opened up, I ſhall only in general add, that deep ploughing, in the ordinary operations of tillage, *at every time it is ſtirred*, is by no means neceſſary.—(See farther on this ſubject, Eſſays on Agriculture, vol. iii. p. 298.)

I cannot omit, however, on this occaſion, to take notice of the abſurd impolicy of that rule which prevails in moſt counties in England, of prohibiting graſs lands from being ploughed. In all caſes of this ſort (and many millions of acres of this deſcription of land are found lying in the moſt unprofitable kind of graſs) it is the ſame thing as dooming the beſt land to a ſtate of perpetual ſterility—for ſuch land, when ſuffered to lie in its natural ſtate, produces next to nothing in graſs; yet by a ſpirited and judicious mode of culture, continued for a ſufficient length of time, it becomes the moſt productive of all ſoils. I could eaſily point out ſoils of this kind, which, if left to graſs, in their natural ſtate, never could have yielded half a crown of

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rent per acre, that have been brought, in the ſpace of a few years, to yield crops of wheat from ſeven to nine quarters per acre; a weight of crop that no ſoil I know, but thoſe of which I now treat, could ever be made to produce.

Were I to call thoſe improvements, *diſcoveries*, which are merely the reſult of the exerciſe of the common powers of reaſoning from facts that daily occur; and were I to value ſuch diſcoveries in proportion to the extent of their utility to mankind, I ſhould perhaps reckon the above one of the moſt important diſcoveries that has been made in the art of draining in the preſent age; becauſe, for *one acre* of land that can be drained by means of tapping, there are perhaps ſeveral *thouſands of acres* in this iſland which may be benefitted in a very high degree by this very ſimple proceſs. Indeed, unleſs it were for the ſurprize that the mode of draining on the principle of tapping excites, at firſt, upon the mind of thoſe who have not adverted to things of this kind, and the quickneſs of the effect it ſometimes produces, at little or no expence, where *it is well underſtood*, and properly

perly applied, it muſt hold an inferior rank to many other modes of draining that have been long practiſed, becauſe of the much ſmaller *extent* of the evil that can thus be removed than by many of the other modes of draining that are developed in this Treatiſe. More miſchief is often produced by a ſingle ſpring, in the caſe I am juſt about to illuſtrate, than is experienced in a whole county by that peculiar kind of wetneſs which *can* be removed by tapping. Of the bogs that are found in this iſland, perhaps not one-thouſandth part of them could be reducible to that claſs which admits of being cured by tapping. I now proceed to give a few additional illuſtrations, with a view more clearly to elucidate the principles already explained.

As the whole ſucceſs of practical draining depends upon accurately diſcriminating between the caſes already ſtated (though, perhaps, with too much brevity) in the foregoing parts of this Eſſay, my chief aim in theſe Additions, ſhall be, ſo to mark theſe caſes, as to enable the reader to diſtinguiſh them. This he will find no difficulty to do where the caſe is

is *ſimple*; but in compound caſes, he may be, on ſome occaſions, a little at a loſs. Theſe difficult caſes are, however, very rare, and if he be attentive, he will, after a few trials, be eaſily able to diſcriminate them alſo.

Let the reader never loſe ſight of the fundamental principle, that all ſprings are produced in conſequence of the water which falls from the atmoſphere, upon high grounds, ſinking through ſome kind of porous earth, until it comes to a bed of clay or granite, or other matter that is impervious to water, ſtopping it from ſinking farther, and, of courſe, forcing it either to riſe upwards, as in a reſervoir, till the cavity be filled, or making it find a paſſage through ſubterraneous pervious ſtrata, till it reaches the ſurface of the earth, where, according to the circumſtances of the caſe, it either iſſues at once a pure ſtream of clear water, running forward in rills to the neareſt ſtreams, or oozes obſcurely forth through innumerable ſmall orifices, into the porous vegetable mould, which produces that wet

weeping appearance, denominated *ſpouting ground* or *bogs*.

It will be unneceſſary here to accumulate particulars, reſpecting clear ſprings. In general, where theſe occur, little more is required by the farmer, than that the channel be ſo opened up, as to allow that water to flow off in a free current, in the direction that nature points out; in ſuch a way, however, as never to force it, or even to permit it to be abſorbed and loſt in the ſoft vegetable mould that may chance to lie in its way on its paſſage towards the ſea.

And here I may be allowed to obſerve, that thoſe who wiſh to get a clear idea of the principles of draining, will do well to begin their ſtudies in mountainous or uneven countries, rather than in plains; for, in the firſt caſe, they will meet with many facts, that are obvious on a ſlight inſpection, which cannot, without great difficulty, be made apparent in a flat country. It is, perhaps, owing to an inattention to this circumſtance, that ſo few men who have *practiſed* draining, have underſtood the principles of their art; which is doubtleſs

the cauſe of thoſe numerous failures that have been experienced in the *practical* efforts of thoſe, who, in certain caſes, have performed cures, that merited the higheſt degree of applauſe.

Where a ſtratum of ſand, rock, gravel, or other porous matter, lies in a regular ſlope towards the earth's ſurface, ſupported by a bed of clay (as in Fig. 25) if that ſtratum has not been deranged by earthquakes, or other violent convulſions of nature, it uſually ſtretches back to a great diſtance, perhaps at a great depth beneath the ſurface of the hill, and where it crops out, as at A, if the ſtratum runs in a horizontal poſition (which is often the caſe) when viewed at right-angles to the ſection here given (which exhibits the natural dip of the ſtrata) it there forms a kind of zone, running along the brow of the hill, nearly in a horizontal direction, for a great way. I have often thus ſeen a zone of this kind, running along the brow of a hill, nearly at the ſame height, for miles together; its courſe being marked every where, by a wet uncomfortable ſtripe, of inconſiderable breadth, frequently broken into ſmall holes, by the feet of cattle, or

other accidental circumſtances. Where-ever this indication appears, you may, with next to a moral certainty, conclude, that the evil originates from this ſource, and you may, therefore, boldly adopt the mode of cure that has been already indicated for this evil; ſee page 72. A ſmall ditch opened all along the lower part of the ſpouting zone, that ſhall be, in every caſe, ſo deep as to paſs through the pervious mould, and ſhall penetrate into the bed of clay, or other impervious ſtratum below, will with certainty intercept the water, and remove the evil, in as far as affects the lower grounds.

Thoſe who have not turned their attention to this ſubject, will ſcarcely be able to form an idea of the benefit that may be derived from this ſimple and eaſy proceſs. I have frequently ſeen, in commons, and other neglected places, where the hand of induſtry has never been exerted (eſpecially in Wales) that a ſpring of this kind has drenched fields for miles together, rendering the ſoil one univerſal cold ſoft kind of ſwamp, unfit for producing any kind of vegetable, that is nutritious either for man

or

or beaſt; for wherever the ſurface ſoil is ſo tender as not to be capable of carrying the water, it ſinks through that, and endeavours to force a paſſage for itſelf towards the bottom of the hill, along the top of a bed of clay, frequently mixed with ſtones, that will, in general, be found at no great depth beneath the ſurface. And as this water is thus interrupted in its courſe by the reſiſtance of the quaggy mould, it is alternately ſeen to riſe upwards, running through ſmall pores, till it flows forwards a little on the ſurface, and then ſinks downwards through the ſoil again. Millions of acres of land have I ſeen, that have lain in this neglected ſtate for ages, which is unfit for any thing elſe except that of rotting the few miſerable ſheep that are ſuffered to ſtraggle along its ſurface, and might be drained at an expence that is inconceivably ſmall.

All that is required for draining land in this ſtate, is to cut ditches acroſs the ſlope, nearly in a horizontal direction, giving them merely ſo much dip as to allow the water to run off through them freely. Theſe drains muſt always penetrate, at-leaſt, one foot or more, in proportion to the quan-

tity of intercepted water, into the *solid* bed, below the soft surface-earth; and this surface-earth seldom exceeds one foot in depth. The earth that is taken out of these ditches, where it is not meant that it should be made to serve as a fence, ought always to be laid upon the *lower* edge of the bank. There, by its weight, it will serve to consolidate the earth on the lower lip of the ditch, which will make it better resist the entrance of the water, in time of floods, when the ditches may be fuller than usual.

No sooner will such a ditch be made, than the water will be seen to trickle into it, from the higher side, through the whole depth of the mould; but it will also be seen to flow most freely immediately above the clay. The lower part of the field, thus deprived of the sources that used to supply a perpetual moisture, will, in a short time, become drier than before; but it will require a considerable length of time to allow the whole water gradually to drain from it. And as the water that is nearest the ditch must pass through the whole of the soft ground

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below, before it can make its efcape; it is evident that if the flope be long, it will require a great while to free the lower parts from wet. To facilitate this operation, other drains of the fame fort fhould be drawn, nearly parallel to the firft, at fmall diftances (from one to two hundred yards) below each other. This will not only accelerate the operation, but it will alfo enable you to intercept, and thus to difcover, any concealed fprings that may accidentally break forth in any part of thefe neglected waftes.

I would here mention, that if in driving your ditch, you fhould accidentally crofs a bed of fand that lies deeper than the bottom of the earth, care muft be taken to obviate this evil, were it not fo apparently neceffary as fcarcely to deferve being mentioned. The way of obviating this evil will be gathered from the general tenor of this Effay, and need not be here particularly fpecified.

When a bed of fand, which ferves as a receptacle of fprings, inftead of terminating abruptly on the furface, as at A, Fig. 25, extends to a confiderable diftance,

in a direction nearly horizontal, as from A to B, Fig. 26, the circumſtances will vary. In that caſe, if the hill from whence it iſſues, be of conſiderable extent, whether of great height or otherwiſe, the water will flow throughout the greateſt part of the year with a ſtream pretty equable; and if the bed of ſand be moderately deep, that water will never be forced ſo far upwards among the ſand, as to prove hurtful to vegetation; and it will form a field of a dry ſandy ſoil.

But if ſome grounds riſe above this to a conſiderable height, which are ſo formed as to throw the water that runs from them, during violent rains, into places where it can ſink freely into the bed of ſand, it will then force forward a much larger ſtream of water towards A, than at other times; and, of courſe, that water will riſe to a greater height among the ſand than before (and the ſame phenomena will occur, if the ſurface-water, during rains, be brought from a great diſtance, till it reaches the upper part of the bed of ſand, towards B, where it will be abſorbed). In that caſe, the under part of the bed of

ſand,

ſand, towards A, where it is not ſo deep as above, will become very damp, while that above will remain dry. When this caſe occurs, the cure is, to dig a ditch acroſs the field, at the place where the wet firſt begins to ſhow itſelf during the wetteſt ſeaſon, quite through the bed of ſand, till it penetrates into the clay (as in every caſe of this ſort) the open part of which muſt be of ſuch a ſize as to carry off the whole of the water it intercepts in its courſe. In theſe circumſtances, however, it will be well to obſerve, in the firſt place, whether the bed of ſand be not interrupted at its lower end, by a bed of ſome more impervious matter, which, by preventing the water from flowing off as faſt as it comes to it, forces it up towards the ſurface; for, in that caſe, it will be, in general, much leſs expenſive to open a ditch through the impervious ſtratum, that interrupts the ſtratum of ſand in its bed, and running that ditch up the hill, till it comes forward to the ſand; and to make it of a ſufficient depth, which will give free vent to the water, than to drain the field in any other way.

This is a cafe that ought to be carefully adverted to; for no foil that I know, is more worthlefs than a damp fand.

In all the cafes above fpecified, it is very obvious that no fort of benefit could poffibly be derived from the practice of tapping.

Nor, unlefs in the very laft-named peculiarity of the cafe, could drains, if carried in a direction *up the hill*, afford any efficacious remedy, even if they were made at a very fmall diftance from each other; for the water would follow its courfe down hill between the drains, nearly as before the drains were made.

The doctrine of wells being fo intimately connected with that of draining, I fhall hold myfelf excufed for making fome remarks on that fubject, where they are incidentally fuggefted by the circumftances treated.

Let it be obferved, then, that in cafes of the fort now under difcuffion, if the water were fuppofed to have a free iffue at A, were a well funk into the bed of fand, at B, no water could be there permanently found until it penetrated quite through the

ftratum

ſtratum of ſand, and went to ſome depth into the bed of clay below it. In this caſe, the water could never riſe in the well much higher than the line *b c*, Fig. 27, becauſe, whenever it roſe as high as the porous ſand, it would flow along through it, till it made its eſcape below; and if the bed of clay extended backwards under ground a great way, and at a great depth below the ſurface, ſo as to form an abundant and never-ceaſing ſtream under the bed of ſand at B, it muſt follow, that the well will continue conſtantly at the ſame height, exactly like a ſtone baſon at a fountain, into which a pipe of water conſtantly flows, ſo as to keep it running over. This happened to be exactly the caſe with a well of water that was at my door in the neighbourhood of Leith. A bed of ſand reached from the ſurface, to the depth of twelve feet, nearly; the well had been ſunk about three feet in the clay upon which the ſand reſted, and the ſtream of water was ſo abundant as to keep that part of the well which was ſunk in the clay conſtantly full, ſo that it was ſcarcely ever known either to ſink or to riſe

riſe ſix inches above or below its ordinary ſtream.

But if the ſtream that runs below the bed of ſand be ſmall, and the draught of water from the well, at particular times, be uncommonly large, the ſurface of the water in the well will of courſe be made to ſink: it may be indeed quite drained of water at times, ſo as to require to be left for a while till it ſhall fill again. This may be occaſionally a very ſerious inconvenience, and ought to be guarded againſt by enlarging the reſervoir, which may be effected either by widening the diameter of the well, or by ſinking it to a greater depth in the clay, or both. Hence, it appears, that *in caſes of this ſort*, a very *wide* well ought always to be made. Other caſes will come to be noticed in the courſe of this Work, in which the ſtraiteſt well that can be made, would ſupply a quantity of water as abundant as thoſe that are wider.

Nor would the phenomena here deſcribed be in the leaſt varied if the well, inſtead of being dug in the ſand immediately below the vegetable mould, as at

B, ſhould be firſt ſunk through a conſiderable thickneſs of ſome other ſtrata, as at C. The depth of the well only would be greater, and all other circumſtances the ſame.

Pleaſe alſo obſerve, that if there be an opening at A, ſo as to allow the water to iſſue freely from the ſurface of the bed of clay, the body of ſand above it will be a firm ſolid body; and in this caſe, if houſes are founded upon that ſand, with the precaution of putting planks of wood, or large flat ſtones, as a foundation for the walls, theſe buildings will remain as ſtable for ages, as if they had been founded on a rock. This is preciſely the caſe with the town of Leith, the ſea-port of Edinburgh, the houſes of which all ſtand upon a bed of ſand from eight to twelve feet deep; and there are houſes there of more than a hundred years old, the walls of which are now ſtanding as true to the plumb, as if they had been built but yeſterday. But if, inſtead of having had a free iſſue at A, the bed of ſand had been there interrupted as at A, Fig. 21, the water, in this caſe, would have been regorged back

back among the ſands, and, perhaps, would have formed a bed of that unmanageable body, which architects ſo much and ſo deſervedly dread, under the name of *quick-ſands* *; and which, when it comes in the way in digging wells, or other ſubterranean operations, preſents obſtructions that can be only with great difficulty ſurmounted.

The obvious cure of this diſeaſe (quick-ſands) when it occurs, is to ſearch for the means of opening an outlet by which the water may be ſuffered to run off.—This,

* An apology may, by ſome, be judged neceſſary, for here incidentally mentioning *quick-ſands*, as a thing that may, perhaps, be thought in ſome meaſure foreign to the ſubject. As I aim at giving clear and diſcriminative ideas on every caſe that may occur in the practice of draining, and as this caſe may, and certainly does, ſometimes occur; it does not ſeem to be foreign from the object of this diſquiſition: and it appears to be the more neceſſary at preſent, as I do not know that any ſatisfactory explanation has ever yet been given to the public, of the circumſtances which give riſe to the phenomena of quick-ſands; and of courſe, no rational method of removing this diſtreſsful malady has ever yet been attempted. A very able engineer, ſome years ago, from a total inability of forming clear ideas on this head, made ſome very ridiculous eſtimates of improvements propoſed at Leith; which he never could have done had he been better informed on this head.

where

where the quickſand is ſituated above the level of the ſea, or ſome adjoining plain, may in many caſes be effected at very little expence; if due attention be beſtowed upon the poſition and natural dip of the ſtrata, which may be diſcovered by various means beſides boring.

But there are caſes, particularly where the quickſand is produced by a cavity like a baſon ſcooped out of the entire bottom, ſo as to contain water to a conſiderable depth, which in ſome particular ſituations may be deemed incurable.

It deſerves alſo to be remarked, as a circumſtance neceſſarily accompanying ſprings of this kind, that the digging wells in a higher poſition, as at C or B, will not ſenſibly diminiſh the quantity of water that flows over the lower ſurface of the clay towards A; for, as the well, as ſoon as it is filled, muſt overflow; that will intercept not one drop more water than what is drawn up out of it. Were it even poſſible to pump the water from the well, as faſt as it falls into it, ſo as never to allow one drop to run over, the caſe would not be much altered; becauſe no more water could be thus

thus intercepted than that which would have flowed into the mouth of the well in its defcent, fo that every drop that would pafs the mouth of the well, on either fide, would flow forward to the lower fituation, as if no well had ever been made. Hence we fee that fprings of this fort can never be intercepted by wells, or fenfibly affected by other wells placed either higher or lower than them. Wherever this cafe exifts, water will be found nearly in equal abundance, whatever the relative fituation of the well may be in refpect to others; nothing but an *uninterrupted trench*, of a fize fufficient to intercept *all* the water as it flowed, and to carry it off, could dry up the fprings below it.

We may alfo obferve that if the bed of fand be of great extent, if it be at laft fupported by a bed of clay or other impervious matter, water will undoubtedly be there found, whatever may be the depth of the bed of fand above it, if a well be dug through it; for, as the water that falls in fhowers upon the earth's furface neceffarily finks through that pervious ftratum, it is foon beyond the reach of the fun, fo as not

to

to be evaporated, and muſt ſink downwards till it meets with an impervious ſtratum, ſo that there can be no doubt but that under the immeaſurable deſerts of Lybia, there muſt be water in abundance, to ſupply any number of perſons, were wells there ſunk to the requiſite depth: Nor is that depth perhaps, in many caſes, nearly ſo great as has been in general apprehended.

I may here alſo be permitted to obſerve, that many inſtances occur of ſtreams of water flowing over the ſurface of beds of ſand of the kind here deſcribed, without ſinking into theſe ſands. Sometimes the ſurface-ſand is even rendered hurtfully wet by water ſtagnating upon it, while ſprings of the ſort above deſcribed, are freely running below. This phenomenon is occaſioned by a natural proceſs, ſimilar to that which is now adopted for rendering canals retentive, called *puddling*. When this happens to be the caſe, the ſtagnating ſurface-water may be let off merely by digging a hole till it penetrates the cruſt which has been rendered retentive by means of the natural *puddling* proceſs, and till it reaches the unmixed ſand, through which it will

ſink

ſink with the greateſt facility. I have often, in this manner, opened up a hole, in the ſpace of half a minute, in ſuch ſituations, which has ſwallowed up at once a ſtream that flowed into it, which was ſo abundant, that, with a moderate fall, it might have turned a mill; and which if not thus let off, might have produced very extenſive miſchief, by flowing over the ſurface of the ground. In ſuch caſes, the ſmall opening thus made, in a ſhort while, becomes *puddled* ſo as to be retentive, and thus cloſes up, ſo that a freſh hole muſt be opened, if the ſtream continues long to flow, where much mud is carried with it.

Let us again ſuppoſe that A B (Fig. 27) repreſents a ſtratum of ſand, gravel, ſtone, or other pervious matter, lying between two beds of clay, E F and C D, which unite at the point A, where the ſtratum of ſand is interrupted. In that caſe, the water which flows from B towards A, when it reaches that point, will be pent in, as if in a horn, ſo as to have all the vacuities filled with water till it riſes to B, or ſome other point where it can be permitted to flow off. If the upper bed of clay, E F, be of a ſuffi-

cient

cient thickneſs and tenacity to reſiſt the whole preſſure of the water below, the ſurface ſoil will be in no manner incommoded by it; but if that bed of clay be not very thick, the water will be ſqueezed upwards through any ſmall cracks that may occur, producing ſpouting-ground or bogs on the ſurface, as deſcribed in the Firſt Part of this Eſſay. In a caſe of this ſort, it is very plain, that no ſurface-drains could afford any adequate relief—for while the water is ſuffered to remain in the reſervoir below, no operation performed upon the ſurface can prevent the water from being puſhed upwards, through the natural channels it will find for itſelf. In this caſe, tapping is the only remedy, which, by giving free iſſue to the water through an opening made for that purpoſe, in the upper bed of clay, diminiſhes the altitude of the confined water within, and, of courſe, removes the preſſure from below; which, as it was the ſole cauſe of the malady, a radical cure muſt thus be effected.—The only queſtion, then, that now requires to be decided, is, "In what manner ought we to

 proceed,

proceed, ſo as to effect a cure, *at the leaſt expence poſſible to the employer?"*

Let us ſuppoſe that the whole ſurface between G and L is hurt by ſuperfluous water—but that towards L, the ground becomes gradually ſounder, the ſurface near L being only wet during rainy weather. In this caſe, ſhould a ditch be drawn along the face of the hill at L, in a direction nearly horizontal, allowing only a ſufficient declivity to carry off the water in it, it is plain that this ditch, unleſs carried to a very great depth, at an enormous expence, could do little or no ſervice.—And if it were here tapped, by boring a hole through the bed of clay, as is repreſented by the line at L, the relief it would afford would be very inconſiderable; as it could, at the utmoſt, give vent to the water only until it ſunk to the level L K, ſo that all the parts of the field below L would be little better than before.

Should another ditch be opened in the ſame manner, lower down the declivity, as at M, and ſhould it be there alſo tapped, the water would then be allowed to ſubſide

to

to the level-line M N; and all the ground between L and M would be effectually drained. In this case, we have derived some benefit from our operations, though at an expence greatly more than was necessary; for if the operations at M had been first made, the drain would have been as complete as it now is, though nothing had been done above—All that has been expended on the operations at L, then, would be money thrown away to no purpose whatever.

Still, however, the ground between M and G is in want of draining, and we must now go lower down: Suppose we should go at once to G, and there make a similar ditch and tapping; in that case, the water would be made to sink to the level G H, and the whole field effectually drained at once. It is scarcely necessary for me now to remark, that had this been done at the first, the field would have been as effectually drained, without any of the operations above. I state these particulars, here, by way of illustration, as a caveat which ought not to be neglected—for I have often observed, that men who attempt to drain land, without understanding the principles of the

art, have a great propenſity to follow the mode of conducting their operations above deſcribed, who, if not reſtrained, may, in many caſes, ſubject their employers to a moſt exorbitant and unneceſſary expence, even where they do at laſt ſucceed in the purpoſe intended.

Obſerve, however, that in this particular caſe, had the tapping been made lower down, as at I, no good whatever could have been derived from the operation at that place: As this caſe but rarely occurs, yet from this illuſtration the uſe of the previous boring for exploratory purpoſes is made very manifeſt.

It has been ſhown in the Firſt Part of this Eſſay, in what caſes a ditch opened upon the *upper* edge of the wet ground is required for effecting a complete drainage— to which the reader is referred.

The ſureſt rule, I can at preſent think of, for diſtinguiſhing the caſes, where this mode of proceeding (that is, by means of a ditch carried acroſs the declivity, above the higheſt part of the wet ground) will be uſeful, from thoſe in which it muſt prove nugatory, is this: Wherever the water that is to be carried off, can be made to find acceſs

into the ditch only by means of *tapping*, there the opening of a deep ditch, in this situation, may be declared nugatory—and wherever a ditch in that situation can prove radically useful in draining the lower grounds, there tapping can prove of little or no service whatever.

Another economical consideration, that ought never to be lost sight of, is, that in the mode of draining by means of tapping, ditches of a *great depth* can never be required, so that if deep ditches are ever made where this mode of draining is adopted, it must be accounted a mere *useless expenditure of money*. The only use of the drain, where tapping is beneficial, is not to *intercept*, but merely to *carry off* the water.—And if the drain be of a size just sufficient to carry off all the water that rises through tap-holes, nothing more can be required. In general, a ditch of two feet deep will effect this purpose as well as if it were twenty—but the expence of making it will be very different.—As there are men, however, who value things merely in proportion to the money these things cost them—it deserves the consideration of *practical* drainers,

 whether

whether it would be *prudent* in them, to lay aſide expenſive and ſtupendous operations, which often ſtrike the imagination of men, and thus make the improvements which ſeem to require this expenſive apparatus be attended to, when trifling operations, though equally efficacious, would be neglected and deſpiſed? Let Noblemen, and others of high rank, then, be indulged in theſe expenſive and ſhowy operations— the country is benefitted by them—But if ever practical farmers ſhould engage in undertakings of this ſort, it is proper they ſhould advert to the article expence, as of the firſt importance.

In all caſes of this ſort, now under conſideration, where the current of water that flows in the pervious ſtratum is not very great, and where that ſtratum continues without interruption, and undiminiſhed in ſize to the bottom, the drainage will be completely effected, by tapping in the *loweſt* part of the field only.—But where the depth of the pervious ſtratum is diminiſhed conſiderably, as at A (Fig. 28) or, what comes to the ſame thing, where it meets with caſual though not total interruptions-- and

and if the current of water ſhould be conſiderable, it may happen that a ſmall part of the water only (viz. leſs than flows into this reſervoir from above) can reach the point A, and as no more water than reaches that point can be made to riſe through the holes there made, it muſt in this caſe happen, that the drainage will not be completely effected by the opening at A. In that caſe, after trial has been made, and time allowed to ſee whether the drainage is complete or not—ſhould it then be found neceſſary, it will be proper to go higher up, as to E, and there open ſome freſh taps; and ſhould that be ſtill found inadequate for the purpoſe intended, go ſtill higher, to D, and ſo on, higher and higher, till it be finiſhed.

In caſes of this ſort (which are rare) it will be proper always to *begin* at the lower extremity—and if water riſes at all where tapped, be ſure to make the tappings ſufficiently numerous to allow the whole of the water that comes to the place where they are made to iſſue freely. You will eaſily know when theſe openings are ſufficient for the purpoſe—for, in that caſe, after a

ſhort while, the water will not ruſh up through them with great violence, but will flow off gently, without any appearance of boiling up.—If that appearance of boiling does not ſubſide, it is a ſure indication that a greater number of tap-holes are wanted—and they ought to be made. If this be firſt done, and you find that even in the wetteſt ſeaſon, the water riſes gently through the tap-holes, you may then, in general, be ſatisfied that no opening above will be wanted; but in order that no doubt may remain on this head, you may eaſily ſatisfy yourſelf, at a very ſmall expence, whether any openings above are wanted, merely by putting down a bore by your tapping implement, at ſome little diſtance above the former opening. If the water, in that caſe, riſes in the tap-hole you have juſt made, it is a ſure indication that openings at that place are wanted; and, therefore, a drain ſhould be there opened, and taps ſunk in it, as before—but if during the rainy ſeaſon no water riſes through the tap-hole, it is an indication equally clear that no openings are there wanted. In this manner, by boring only, without making drains, until

you

you see whether they are necessary or not; you may proceed upwards, till you ascertain the facts with precision.—By means of the boring instrument, also, you may ascertain with precision the nature of the strata, and their limits, where they are broken or interrupted, so as to be able to know with certainty, before you commence your operations of expence, in what manner you ought to proceed. General ideas, collected from external appearances, may serve very well to direct in plain cases, or to indicate where anomalous cases occur; but in difficult cases, particularly where the strata are broken and jumbled together, external indications can only produce guess-work. The borer only can be relied on.

It will not be expected that I should here enter upon an enumeration of anomalous cases; for these may be so much varied, as that a complete volume could give but a partial statement of them. Fortunately, cases of this sort are few, and of comparatively small extent. There are particular cases where the strata have been much deranged, more especially where rocks intervene, in which the expence of draining

draining would be much more than could be repaid by the ſubject. But theſe bear ſuch a ſmall proportion to the fields that could be drained with profit, as ſcarcely to deſerve to be named in a treatiſe which relates to practical caſes alone.

I have already mentioned ſome caſes that relate to digging for wells. The following caſes are of a different claſs:

Probably, ſome of my readers may recollect having read in the Philoſophical Tranſactions, ſome years ago, an account of the phenomena that occurred in ſinking a well at Sheerneſs, near the mouth of the river Thames; ſome of which phenomena were deemed, by many perſons, rather of a wonderful kind. They were as follows: That fort is placed upon a neck of land, very little elevated above the ſurface of the ſea. In digging the well, they paſſed through a bed of ſolid clay, to the depth of   fathoms, without finding water of any kind; but at that depth, they found a ſpring of *ſalt* water; which, not being irreſiſtibly abundant, they found themſelves enabled to wall it out. This being done, they then ſunk, once more, through

through the ſame bed of clay, for fathoms more. Here they found another ſpring of *ſalt* water, as before; which, having walled out alſo, they continued to dig through the ſame bed of clay, for 300 feet more; at the bottom of which they found a bed of gravel, from which iſſued a copious ſtream of freſh water, which ſoon filled the well within five feet of the top, at which height nearly it has remained ever ſince.

Wonderful as this may ſeem, at firſt ſight, to ſome perſons; it will appear, in no reſpect, inexplicable to thoſe who have adverted to the phenomena that occur in the tapping for ſprings, ſo fully explained in the foregoing parts of this Eſſay. Let A, Fig. 29, repreſent the fort; B the ſea; CDE a bed of ſolid clay, ſtretching out beneath the ſea, and backward into the land to an indefinite diſtance. FGH repreſents a ſtratum of gravel, or other pervious matter, lying upon another bed of clay, IKL. Under theſe circumſtances, the ſtratum FGH, having no opening at the lower end, muſt form a reſervoir of water, which muſt riſe upwards towards F, till

F, till it finds some opening near the surface of the ground, through which it can make its escape. This being the state of things, it is very obvious, that as soon as the well MN reaches the bed of gravel N, the water contained there must be forced to ascend till it reaches as high as the water contained in the internal reservoir within the mountain. If the spring affords more water than is taken from the well, it will continue always at that height; so that the water can only sink in the top of the well, when more is drawn from it than the spring can supply in a given time.

With regard to the salt-water springs, the diagram will explain that phenomenon, at first sight. At P and Q, two fissures, occasioned, perhaps, by the working of some animal, or other unknown cause, have penetrated the bed of clay, from the edge next the sea, to some distance as far inward, at least, as the pipe of the well, through which, of course, salt-water would flow, into the well as soon as they were opened.

Another phenomenon of a similar kind, but

Fig. 25

Fig. 26

Fig. 27

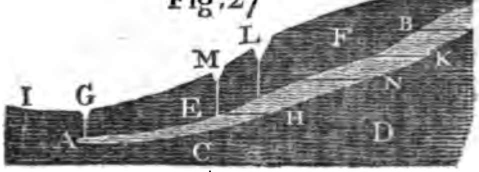
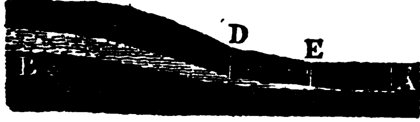


Fig. 28



but leſs complicated, becauſe diveſted of the circumſtance of the ſalt-water, is mentioned by Dr. Darwin, of Derby: A well was ſunk in that town (which lies in a bottom, ſurrounded with many hills). After digging through a bed of clay for ſome conſiderable depth, they found an abundant ſpring of freſh water, which, as in moſt caſes of this ſort, ruſhed up with great impetuoſity, and ſoon filled the well to the top, where it flowed over in a pretty copious ſtream. Dr. Darwin ſeeing this, and conceiving that it might deſcend through a ſubterraneous funnel, that roſe to a greater height than the houſes of the town, eaſily perceived, that if he could raiſe the ſides of the well to a ſufficient height, making them, at the ſame time, ſtrong enough to bear the preſſure of the water, he might get it thus conveyed to the higheſt floors of his houſe. This he actually effected, and enjoys, I ſuppoſe, the benefit of his ingenuity, till the preſent moment.

I do not hear that Dr. Darwin has thought of extending this diſcovery to any other uſe; but if an abundant ſpring

ſhould be thus diſcovered, which could be forced, without the power of machinery, to riſe to a great height, it might, doubtleſs, in a mountainous country, where phenomena of this ſort muſt chiefly occur, be employed to great advantage as a power for turning machinery. To illuſtrate this ſubject, let Fig. 30 repreſent the ſection of a hill, containing an internal ſtratum of pervious matter, incloſed between two ſolid beds of clay; in other words, an internal reſervoir, filled with water. If this reſervoir ſhould be diſcovered, by means of boring, or otherwiſe, as at AB, and it was found that the water would riſe to the height of A; then, by digging a ſhaft, of ſufficient dimenſions, and building the ſides of it as you proceed, till it reaches the gravel at A, then the water would riſe and flow over at A, till the internal ſurface of the water ſunk to the level of the line AC; after which, the whole water that the ſpring ſupplies would continue to flow over at A, and form a perennial ſtream, perhaps extremely abundant; the uſes of which, in ſuch a ſituation, are very obvious.

vious. St. Winnifred's ſpring, near Holywell, Flintſhire, which is ſo abundant as to turn nine mills, is a natural burſt of the ſame ſort with that I now deſcribe (for it is not a great while ſince it firſt appeared). But were the ſpring much ſmaller than it is, the great height of fall that might thus be obtained, would give it a commanding power for turning machinery.

Should an opening of the kind here mentioned be ever made, it is plain that its effects muſt be ſenſibly felt in ſome other place; exceedingly ſo, indeed, if the ſtream be abundant; for a reſervoir of the kind here ſuppoſed, muſt, of neceſſity, have an outlet ſomewhere, for diſcharging its waters; and, as in the caſe here ſuppoſed, that outlet muſt be on a higher level than the other, it could not fail that when this laſt was opened up, the other muſt have failed, ſo that a ſtream which iſſued perhaps from an oppoſite ſide of the hill, poſſibly, at many miles diſtance, would be entirely dried up, and another formed, that might take a direction to the ſea totally different. Theſe phenomena, when thus explained, are as natural as that the ſun

ſhould give light when it ſhines; and can excite wonder in the mind of thoſe only, who have never adverted to the phyſical conformation of our globe. Indeed, the *borer* has been but too little uſed, in conſequence of which, many facts that might have been highly beneficial to man, have totally eſcaped his notice. I ſhall beg leave to ſpecify a few, with a view to direct the attention of the public to this intereſting ſubject:

At Halle, in Germany, a ſpring of ſalt-water was diſcovered, many years ago, which when manufactured into ſalt, affords a great revenue to the King of Pruſſia, in whoſe dominions it is placed. Halle being ſituated very near to the confines of Saxony, the Elector was in the practice of purchaſing brine from thence, which he carried into his own dominions, and there converted it into ſalt, for the uſe of his ſubjects. As the carriage of this brine was attended with a conſiderable expence, the Elector often expreſſed an earneſt wiſh, that a ſpring of ſalt-water could be found in his own dominions. This turned the attention of his people to this ſub-

ject,

ject, and at last an unlettered peasant, in the neighbourhood of Leipsig, presented himself at court, and made offer, at the risk of his head, to find salt-water at a place he should indicate, if the Elector would be at the expence of digging for it. —It was some time before this poor man could adduce such arguments as to satisfy the Electoral council, that there was such a probability of success, as to authorize them to risk the experiment; but at length he prevailed. The work was begun at a place called Durlinberg about 15 miles distant from Halle. For some time nothing extraordinary appeared, but at length they came to a spring—of fresh-water only.—This did not discourage the peasant, who ordered them still to go on. With some difficulty he effected this point; but as the water from that spring incommoded them a good deal, it excited a murmur against the poor man. After digging somewhat farther, they came to a second fresh-water spring, which threw the undertakers into such a rage, that they would not listen to the poor man, who urged him still to proceed; but, on the contrary,

the man seeing them in such bad humour at being frustrated, after having expended so much money, he began to dread some mischief to himself, and secretly withdrew himself from the electoral dominions. Soon after this event, the king of Prussia overran Saxony, during the seven years' war, and the operations at this well were forgotten. When peace was afterwards restored, and the minds of men a little cooled, the peasant ventured to return.— His mind was still set upon completing his enteprize; and he spoke with so much firmness on the head, and adduced such cogent arguments in favour of his opinion, as prevailed upon the court a second time to begin the work; he having the precaution before they began to tell them, that as the spring was probably at a considerable depth beyond what they had as yet reached, they must be determined not to be soon discouraged. They again went on, and, as he had said, they did indeed, when at a very considerable depth, open up a spring of *salt-water*; which rushed into the well with such impetuosity, as soon filled it to the top, over which it flowed,

flowed, for ſome time, in ſuch abundance, as to occaſion conſiderable damage; but this violent burſt ſubſiding by degrees, they began to erect ſalt-works, which continue to be worked till this day. This is one practical proof, at leaſt, of the benefit that ſociety may derive from the ſtudy I here wiſh to recommend. Nor have I a doubt, but if it ſhall be properly attended to, many other benefits, equal to the above, may be derived from it.

It is well known, that at Newcaſtle upon Tyne, and at Bo-neſs, in Scotland, coals are dug at a great depth below the level of the ſea; and even below the bottom, and immediately underneath it.—As no ſalt-water is diſcovered in theſe coal-mines, it affords the moſt demonſtrative evidence, that the bed of clay that lies above the coal is perfectly impervious by water; of courſe, the water which is found in the coal-mines, and which occaſions much expence to diſcharge it, can get acceſs into it in no other way than by deſcending along the tract of the coal-ſeam, from the place where it approaches towards the ſurface of the

 ground,

ground, exactly in the ſame manner that ſprings are accumulated in other pervious ſtrata. Hence it muſt happen, that if this ſtream of water ſhould be intercepted in its courſe, and there carried off to the ſurface of the ground, no water could get into the mine; ſo that all the coals below that interſection would be laid quite dry, by a proceſs in every reſpect analogous to that of intercepting the ſprings, deſcribed in page 72, and with an effect *nearly* equally beneficial. I ſay *nearly* in this caſe, becauſe no operation of this ſort could *entirely* remove the water from the coal-mine; for as there muſt be ſome fiſſures among the coals, through which the water has originally flowed, ſo theſe fiſſures, in a ſituation like that deſcribed, muſt be entirely filled with water, which would of courſe run in the pit, after the coals are taken out, but this would be ſuch a trifling matter, as not to deſerve any notice.

Let A B (Fig. 31) repreſent a ſeam of coals, riſing at A towards the ſurface, and at B dipping beneath the ſea. Let it be ſuppoſed, that at C it has attained ſuch an elevation

elevation as to be above the level of ſome vale or rill of water, and that, of courſe, a level driven from the ſurface at that height, till it reached the coal, might ſerve the purpoſe of carrying off all the water that ſhould fall into it. In that caſe, were the ſtratum of coal there pierced through, as at C, ſuppoſing that to be the only ſtratum permeable by water, it would follow, that all the water which had formerly been conveyed through that ſtratum, would be there intercepted, and carried clear off to the ſurface of the ground; and that, of courſe, all the coal that lies below it, would be, from that moment, freed from any additional acceſſion of water. In this caſe, the level would not only ſerve to free the *upper* part of the coal-mine from hurtful water, which is all the benefit that has hitherto been aimed at in works of this nature; but the *under* part of the mine would be alſo benefitted by it nearly to an equal degree.

Where the ſtrata were ſo diſpoſed, as by varying the direction of the drain, it could be puſhed forward, without falling below the level, till it had cut through

the bed of coal for its *whole breadth*, the cure would be quite complete. This case may probably sometimes occur; but I am as yet too little acquainted with the actual circumstances of this nature, that occur in practice, to be able to say whether it would be very rare, or the reverse. Indeed, as the subject has never been as yet considered under this point of view, I think there is reason to suspect it is not known by any human being. It is certain, that much benefit is yet to be derived from a more thorough investigation of this intricate, though very interesting subject; and every hint that tends to elucidate it in any degree, deserves to be attended to.

It would be impossible to enumerate all the benefits that might be derived from the practice of *tapping*, judiciously applied, were the nature of the strata, and the physical conformation of the earth, sufficiently adverted to.—Were I even to attempt to give examples of *possible* cases, by way of illustration, it would be deemed hypothetical and absurd. Yet it must certainly be deemed more absurd, by every rational person,

perſon, to obſerve, that we allow natural phenomena, which ought to ſuggeſt practical leſſons of wiſdom to the attentive obſerver, to afford only matter of ſtupid admiration. We ſee, in ſome places, rivers ſinking into gulfs in the earth, and diſappearing. In other places, we ſee ſubterraneous rivers iſſuing from caverns, while other rivers are meandering on the earth's ſurface above them.—We ſee lakes of great extent, ſurrounded by mountains, that cannot be drained, according to the ordinary mode of procedure.—Mines are deſerted becauſe the water cannot be carried off from them, on account of the immenſe length of a *level*, that would be required to be driven in order to drain them. All theſe things we ſee as iſolated facts, that cannot be in any way accounted for, or connected together. Yet that they may, on ſome occaſions, be *ſo* connected, as to prove highly beneficial to man, I ſhall venture to ſhow, even at the riſk of being accounted viſionary.

We have ſeen, from the fact reſpecting the well at Tilbury Fort, and the working of coals under the ſea, at Newcaſtle

and Bo-neſs, that water may be preſerved in a baſon of immenſe extent, though bounded by a cruſt of impervious matter, which is of no great depth. Theſe caſes alſo prove, that ſtrata of pervious matter may lie under theſe; of courſe, many oozing ſtreams, or even ſubterraneous rivers, may run, at no great depth, beneath lakes, or rich mines that are drowned in water; preciſely in the ſame way that we have ſeen (page 64) that a ſtream of water may be carried along the ſurface of a bed of ſand, at the bottom of which runs a current of water ſufficient to ſupply innumerable wells abundantly with water; and that this ſurface-water, if the cruſt be once broken, immediately ſinks into the ſand, and totally diſappears. Should any accidental convulſion of nature then break the cruſt that ſupports the lake, ſo as to permit it to find its way into thoſe cavities below it, it would, through theſe iſſues, find acceſs to the ſea, and the lake would be effectually drained; ſo as to become, in time, like the kingdom of Cachemire, a fertile vale, though every where ſurrounded with hills, through which no outlet could be

had,

had.—Might not the ſame effect be produced by the ingenuity of man, were he at pains to exert his faculties in caſes of this ſort? An earthquake, it is ſuppoſed, opened a paſſage through the mountains of Cachemire, by which the water iſſued, ſo as to drain that immenſe lake, and through which the river which traverſes that bottom ſtill flows. An enterprizing individual, who poſſeſſed a ſmall lake on his property, near Glaſgow, effected a drainage, in imitation of this, by digging a level paſſage through a ſurrounding hill, through which the water flowed off, and which ſtill operates as a drain. Many caſes may occur, in which a ſimilar drainage might be effected, at a much ſmaller expence, by ſinking a pit downwards, through which the water might iſſue by ſubterraneous paſſages; and in the ſame way, at times, it may doubtleſs happen, that water might be let off from mines at a very ſmall expence, compared with that which the driving a level might have coſt. Wherever operations of this ſort are in contemplation, therefore, it behoves the owners to advert to theſe peculiarities,

and

and to be at more pains to acquire an accurate knowledge of the ſubjacent ſtrata, in hilly diſtricts eſpecially, by means of accurate obſervations, aſſiſted by boring, than has hitherto been done. For in this way, doubtleſs, very great improvements may be made at a trifling expence.

With a view to illuſtrate this branch of the ſubject ſtill more clearly, I have added a diagram (Fig. 32) which is intended to repreſent a ſection of a hilly diſtrict, in which A B repreſents a lake of indefinite magnitude, every where ſurrounded with hills, which raiſes the water to its preſent level, where it finds an outlet at A, and flows from thence in a valley between the hills, till after running thus many miles, if you pleaſe, it precipitates itſelf over the rock C.

At the bottom of this hill, C, iſſues a conſiderable ſtream of water from a large cavern, like one of the ſame kind near Matlock, in Derbyſhire. This ſubterraneous river, we may ſuppoſe, indeed, we may be aſſured, flows from a great diſtance backward. If it be of a large ſize, it muſt have come many miles, indeed,

flowing all the time through open rocks, or other pervious ſtrata, in a direction nearly ſimilar to that marked DE, which may be expected, in general, to lie at a a depth rather above than below the level of the opening from whence it iſſues. Under theſe circumſtances, it is plain, that if an opening were made in the bottom of the lake, as at G, the water would ſink directly from the lake, into the channel of of the ſubterranean river, and if that opening were large enough, the whole water of the lake would ſink through it, and it muſt, of courſe, be effectually drained.

Again, let us ſuppoſe that F repreſents a mine of lead, or other metal, which has been there diſcovered, but which is ſo drowned in water that it cannot be worked with profit. According to the uſual practice, the owner of that mine has no other way of draining off this water, but by taking the depth of the bottom of the mine, and ſurveying the ground around it, ſo as to be able to mark the neareſt place on the hill ſide that is on a level with the bottom of his mine, and from thence he derives a level C F till he reaches the mine. In many

ſituations,

ſituations, that level may require to be driven ſeveral miles in length, before it can reach the mine, the expence of which can never be repaid, and therefore the mine muſt be abandoned for ever.—And where it is even found that the mine is ſo rich as to afford the expence—yet the time that muſt be expended on this operation (where one or two men only can be permitted to work at once) is a moſt diſcouraging circumſtance, as five, ten, or even twenty years may be expended before it can be completed.—But, in the ſituation here deſcribed, it is evident from inſpection, that if a perforation had been made right downwards, from F, it would ſoon have reached the ſubterranean river, and thus have freed the mine from the extraneous water, at an expence inconceivably ſmall.

Not only could the hurtful water be thus eaſily abſtracted, but other uſes could be made of this ſubterranean drain, that would prove highly beneficial to the undertaker.—If a ſmall ſtream of water, for example, could be brought to the mouth of the pit, it could be employed, by means of a chain and buckets, to raiſe up the whole of the ore to the ſurface, at next to no expence to the

undertakers;

undertakers; or, after ſpace ſufficient for that purpoſe was once worked out, it could be made to drive ſtampers below, for ſtamping and waſhing the ore, there, before it be brought out of the mine, and for other uſes.

Nor let it be thought that theſe are chimerical or impracticable notions: There are many ſituations, already known, upon the earth's ſurface, where theſe operations might be undertaken not with a *probability* only, but with a *certainty* of ſucceſs. The river Guadiana, in Spain, ſinks at one place into the earth, and after running under ground for ſeveral leagues, riſes again to the ſurface. —Now as no holes have ever been diſcovered in the bowels of the earth, reſembling a bored pipe, or mole-rut—but the openings there, through which water flows, are univerſally found to conſiſt of porous ſtrata, which ſpread out in breadth to a great extent—there is a moral certainty that there muſt lie beneath the ſurface of the ground, every where between the place where the river ſinks, and where it riſes, a large ſtratum of pervious matter, which probably ſtretches to a great extent on either ſide,

and that, of courſe, if any mines were diſcovered in that tract, they could, with *certainty*, be drained in the manner here propoſed.

It is alſo known, that in the hill called Ingleborough, in Yorkſhire, there are many openings, called there *Swallows*, into which rivulets precipitate themſelves, and are loſt. Where theſe ſtreams re-appear, I do not at preſent know; but wherever it is, there can be no doubt that all the tract between the one place and the other muſt be hollow, and of courſe, could readily admit of the mode of draining here propoſed.

It is alſo known, that in Derbyſhire, the river Dove, I think (I quote from memory) ſinks into the earth, and at a conſiderable diſtance riſes again.—Subterraneous rivers are known to iſſue, alſo, at other parts in Derbyſhire, and in Devonſhire, in Denbeighſhire, and ſeveral other places, I have not taken notice of; all of which give ſufficient indications of a ſimilar general organization, to render it next to certain, that in thoſe regions, operations of the ſort here recommended, would prove ſucceſsful. The ſame concluſion may, in general, be inferred

inferred in all the mountainous regions, where very copious ſprings burſt forth, whoſe waters are little affected by the temperature of the ſeaſon, being very cold in ſummer, and warm in winter; for this circumſtance always indicates, that they have come from a conſiderable diſtance within the bowels of the earth—Other indicative circumſtances might be pointed out, which I have not time to enumerate.

Having now, as I hope, *proved* in a ſatisfactory manner, that the mode of draining here recommended is a very practicable proceſs, I ſhall add nothing farther to the length of this Eſſay, than to give a few hints reſpecting the manner in which that operation may be the moſt eaſily effected.

On this head, it will be very obvious, that where much water is in the place to be drained, it would be, in all caſes, a difficult matter, in many caſes impoſſible, to ſink a pit directly downwards, immediately from theſe reſervoirs, by digging. In ſuch ſituations, this operation ought to be effected by *boring*. When, by means of a borer, the ſubterraneous vacuum has been

once attained, a certain judgment can be formed of the expence of the future operations. The width of a bore that can thus be made is, indeed, but ſmall; but much water will be let off through a very ſmall bore, under the circumſtances here indicated, becauſe of the altitude from which it muſt deſcend. If the ſtratum through which the bore paſſes, ſhall chance to be clay its whole length, the hole would quickly become of a ſufficient width to give paſſage to the whole water. But if it conſiſt of harder materials, more bores muſt be made; and theſe, if made in a circle, of no great diameter, pretty near to each other, would give the water a chance, by its great force in ruſhing through, to break down, by degrees, the whole of the circular ſolid, and leave a cavity in its ſtead; at any rate, there are few mines which have ſo much water as could not be let off by a few ſuch bores alone.

With regard to the drainage of lakes; if theſe are of great extent, it will become a matter of greater difficulty and expence;

pence; but as the profit will be great, in proportion to the extent, that circumſtance will, no doubt, be taken into the account. In all caſes, the aſcertaining whether the thing be practicable or not, can be done at a trifling charge; for a ſingle exploratory bore will aſcertain not only the depth to which it muſt be carried, before it reaches the pervious ſtratum, but alſo the nature of the materials through which it has to paſs; and, conſequently will give room for a pretty accurate eſtimate to be made of the expence.

In making this exploratory bore, one circumſtance muſt be particularly adverted to; for as it will be neceſſary to make that bore, if poſſible, in the deepeſt part of the lake, it will be a matter of ſome difficulty to aſcertain whether the ſmall bore, under theſe circumſtances, allows water to flow through it or not? This point, however, may be aſcertained by means of the boring irons alone; for if the mouth-piece be thicker than the rod, it will no ſooner reach the pervious ſtratum below, than the water, ruſhing downward with great impetuoſity around the

 rod,

rod, will prevent the poſſibility of drawing up the mouth-piece any more. To guard againſt this circumſtance, which is to be expected, the mouth-piece ought to be ſo fixed on, as that by turning the rods the reverſe way, it may be unſcrewed, ſo as to be detached from the rods entirely, which may then be drawn up without it. Of courſe, all the joinings of the rods muſt be ſo fixed, as not to be looſened by that reverſed motion.

It will not, however, be expected, that where a large river paſſes through a lake, like the Rhone through the Lake of Geneva, or the Rhine through that of Conſtance; or even much ſmaller ſtreams than either of theſe, could, by a proceſs of the kind here hinted at, be ever ſwallowed up. There are few ſubterraneous ſtrata, we are to ſuppoſe, ſo large as to admit of carrying off a current of ſuch magnitude. But if that ſhould be found to be the caſe, the paſſage for the river into that ſubterraneous ſtratum ſhould be made, not in the bottom of the lake, by boring, but at the edge of it, near where the river falls into the lake; and this paſſage may be

dug,

dug, by hand, of a ſufficient width to ſwallow up the river when flooded, and then the river may be led into it, ſo as never to be allowed to reach the lake at all. But this, for the reaſon aſſigned, can ſeldom be practicable with reſpect to large rivers; and in regard to ſmaller rills, that feed lakes, in general, it will be cheaper (unleſs where the under-ſtratum is clay, and of very little depth) in moſt ſituations, to make a water-courſe all round the lake, nearly in a horizontal poſition (with a gentle ſlope only towards the outlet) to intercept all the rills, and the water that falls from higher ground, and carry it clear off, without allowing it to deſcend into the bottom. In this way, no other water will require to be let off through the bottom hole, than that which ariſes from ſprings within the lake itſelf, which probably are, in many caſes, not numerous.

It is to be hoped the candid reader will receive theſe hints with indulgence, they being intended to throw ſome light upon a ſubject of great national importance, which, if it be underſtood by any one, has

never hitherto been explained with the precision which is necessary to render it intelligible to ordinary readers, for whose use these directions have been made out. On a subject of this nature, I have found, by experience, that it is by no means enough briefly to explain the principles on which a successful practice may be rationally grounded; for it is only a few persons from among the great numbers who may be benefitted by it, who will be able or willing to make the practical deductions that a philosophical mind would see are obvious from the premises. To render a practical treatise generally useful, it is necessary to enter upon particulars in detail, and give special illustrations which philosophical hypercriticism might pronounce to be unnecessary. In the Additions now made, perhaps, little can be said to be new; yet I am inclined to hope, that in consequence of these additional illustrations, the Treatise will be rendered more generally useful than it hitherto has been. I shall only add, that the latter part of these illustrations, especially, were written under circumstances rather unfavourable

able for precision, and therefore claim a share of indulgence from the critic, particularly in what regards their form. As to the matter, no indulgence is requested; for if any thing essential be erroneous, it is of importance that it should be corrected.

CORRECTIONS AND ADDITIONS.

When the above was written, I had no opportunity of consulting the Philosophical Transactions, and was therefore obliged to quote from memory, the fact respecting the well at Sheerness; and the plate was engraved on the idea there expressed. I have since seen the 74th volume of the Transactions, in which, that fact is recorded, and find it only differs from the account given above in one particular, viz. that the uppermost stratum, to the depth of 30 feet, consisted wholly of sand, and that all the water which was found in that part, was salt to the taste; in every other respect, it was exactly as above stated. This circumstance requires no

alteration to be made, as the illuſtration would be the ſame. In a few particulars, of no moment, the caſe reſpecting Dr. Darwin's well, is alſo a little different; but, as this illuſtration is perfectly the ſame, it is not worth mentioning farther.

A caſe a good deal different from this, occured at Languard Fort, which is alſo ſituated by the ſide of the ſea. In digging there for a well through a bed of ſand, they found abundance of water; but, as this was below *high-water* mark, they conſidered it to be ſalt water, and it was owing to an accident alone, that they found it to be perfectly ſweet. They continued to dig down, always finding abundance of ſweet water, until, at the depth of twelve feet, they found it ſuddenly to become more abundant, and perfectly ſalt. On examination, it was diſcovered that the ſalt-water was found exactly at the height of *low*-water; and that all above low-water mark, afforded ſweet water only. This phenomenon was evidently owing to the ſalt-water having had time to penetrate backwards to a great diſtance, where the ſand was below the level at which the

ſea

ſea ſtood continually; but, between high and low water mark, the freſh water in its paſſage towards the ſea, though ſtopped for a time by the ſalt tide, yet ſtill preſſed forward, and retarded its paſſage back through the ſand: Nor is it to be doubted, that, if free acceſs had been given to the water into the well, while the ſand was kept back, that the water in this well would have riſen higher at flood, than at the ebb tide.

But, not to dwell on this unimportant circumſtance, the practical inferences that may be drawn from theſe two caſes, are important. In the caſe of Sheerneſs, no enemy from without could ever entertain the moſt diſtant hope of intercepting the water from the fort. The thing is ſeemingly impoſſible. In the other caſe, the water could be cut off by a beſieging army without much difficulty, if the country ſhould happen to be pretty level; for they would have only to draw a trench between the high land behind and the fort, till it reached either the bottom of the pervious ſtratum, or attained the level of *low* water,

and

and the bufinefs muft be effectually completed.

Another practical inference may be drawn from the cafe at Sheernefs which I may be permitted to mention. Should the flat ground continue for ever fo great a diftance backward, there can be little doubt that through the whole tract between the fort and the higher ground, water will be found, by boring, every where, that will rife in the wells always to the fame level with the well in the fort: for the under pervious ftratum muft of neceffity be continued from the higher ground, or it could not have poffibly rifen in the well at all.

Another practical inference to be drawn from this cafe is, that as wells of frefh water are fometimes found to rife to the furface of the ground, or near it, in fmall iflands, that are at a diftance from the land, there can be no doubt, but in every cafe of this fort a pervious ftratum, covered by one of impervious matter, muft run the whole way from the higher land, under the fea to the ifland, as at Inch Keith, and Inch Colomb, both in the Frith of Forth; and that, of courfe, water will be found

found in that direction every where, if dug for to a proper depth, which will riſe to the ſame level with the well in the iſland. Hence, if water be wanted on the ſea-ſhore it may undoubtedly there be found.

Again, There are a few inſtances of abundant ſprings of good water being found on the top of ſome ſmall peaked hills, of conſiderable altitude, which are detached from all other hills by ſurrounding vallies. In every caſe of this ſort, it muſt be occaſioned by a natural perforation, of the ſame kind with an artificial tap-hole, which reaches lower down than ſome part of the valley around, which divides it from higher ground at ſome greater or ſmaller diſtance, having a bed of clay lying above the pervious ſtratum the whole way. This being the caſe, there can be little doubt, that every where between the higher ground and that hill, ſprings will be found by tapping, which will riſe to a greater height at firſt, at leaſt, than the ſurface of the ground—but it is by no means impoſſible, that if theſe tappings be abundant, the well on the hill will be dried up. Indeed, this is not only not impoſſible but highly probable.—Hence, a

ſort

ſort in that ſituation, may be very eaſily reduced to a great diſtreſs by a philoſophical general who beſieges it.—This cannot be done in the low ſituation of Sheerneſs; nor will the ſame reaſoning apply in all caſes to ſprings upon detached mountains, where the ſummit is more flat and of large extent, and the ſpring of water not very abundant.

Here, alſo, it may afford ſatisfaction to ſome perſons to be informed, that the uſe which is propoſed to be made of water ſinking from above into internal cavities, for the purpoſe of turning machinery (p. 158) is not without example; for, there is a mill of this kind, at a place called *Moulins*, (I quote from memory) in the diſtrict of Neufchatel, in Switzerland, where the water, which falls into a gulf in the mountain, turns the wheel; the mill itſelf, and all the machinery belonging to it, being entirely under ground.

It may be here alſo remarked, that Dr. Derham, having found a ſpring at Upminſter, in Eſſex, which continued at all times nearly at an equal height, both ſummer and winter, wiſhed to infer from

that

that fact, that all ſprings derived their origin from the ſea. This phenomenon, however, has been explained in another manner, by the well near Leith (p. 121) which is a caſe that is by no means rare. It may, indeed, often happen, that a well of this kind may be found lying directly above another ſpring of the *tap*-kind, which may be made to riſe to a great height above it, and which alſo ſhall continue always at the ſame height nearly. Theſe corollaries are ſo obvious, as to require ſome apology for ſtating them— But when *common things* are repreſented as *myſterious arcana*, it is proper that the veil which covers them ſhould be, in ſome meaſure, withdrawn.

After peruſing the above, and adverting that there is not a ſingle principle here illuſtrated, which was not clearly explained in theſe Eſſays, more than twenty years ago— (the ſingle caſe of draining thin clays alone excepted; all that is added here being only illuſtrations of the principles already fully enough explained to every philoſophical enquirer) the reader is left to judge with what propriety the BOARD OF AGRICULTURE has

has prefixed the following exordium, to their account of MR. ELKINGTON's Mode of Draining Land:

"It is (say they) a circumstance hardly to "be credited, that the principles on which "the draining of land depends, should have "remained *so long unascertained*, consider-"ing the great private benefit, and the "many public advantages, which must ne-"cessarily be derived from carrying so im-"portant an art to perfection!!!"

Mr. Arthur Young, in one of his performances, tells us, that he attended a *seance* of a society of philosophers, in France, who had met for the purpose of improving agriculture, the importance of whose deliberations, and the wisdom of whose remarks, he does not mention in terms of the highest respect.——I am well pleased to excuse myself for not quoting the passage, from my being at present deprived of books.—It would be well if that gentleman would take care to have things so well arranged at home, as not to give occasion for strangers to retort upon our own dear nation, in a similar manner.

Fig. 29

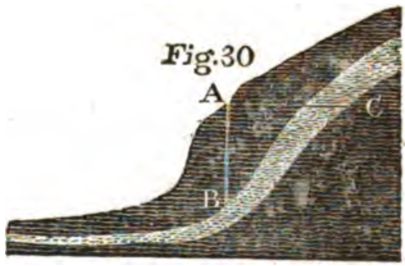


Fig. 30

Fig. 31

Fig. 32

ADDITIONS

MADE TO THE FOURTH EDITION

OF ESSAYS, RELATING TO AGRICULTURE, AND RURAL AFFAIRS.

Of the Uſes of the Balſam Poplar in Fencing.

WHEN the Firſt Edition of theſe Eſſays was printed, the Balſam Poplar was ſcarcely known in Britain. It is now ſufficiently known, as a healthy free-growing tree; and, while young, it is particularly attractive, on account of the firmneſs and luxuriancy of its ſhoots, the grandeur of its large leaves, eſpecially in autumn, and the fragrancy of its buds, in the ſpring. Theſe circumſtances induced me to propagate it in conſiderable quantities, a good many years ago, —and as it can be multiplied with as much facility as the common willow, by means of cuttings, I was gradually led to perceive

that it poſſeſſed certain peculiarities, which rendered it more valuable as a fence, than any of thoſe already enumerated. It has more firmneſs and ſtability than the willow—is more luxuriant in its growth than the Lombardy poplar,—and advances more ſteadily in its progreſs towards a tree, than the elder; ſo that, under judicious management, I have found it the cheapeſt, firm, quick-reared fence for rich lands, in this country, that has ever yet come to my knowledge; on which account, I think it my duty here to deſcribe the mode of management, under which I have found it prove a moſt uſeful aſſiſtant to the farmer:

For obvious reaſons, the perſon who wiſhes to avail himſelf of this kind of poplar, as a fence, ſhould begin with rearing his own plants—and for that purpoſe the *richeſt*, melloweſt, and tendereſt ſoil he can command ſhould be made choice of as a nurſery.—If it has a ſmall tendency to dampneſs, ſo much the better—but if it go ſo far on that ſide as to be denominated wet land, it will not anſwer quite ſo

well.—Cuttings from well ripened wood, of two years growth, are beſt; but where they are ſcarce, others, older or younger, need not be rejected. The cuttings may be about one foot in length, and ſhould be planted in rows, about eighteen inches diſtant, and three inches between each plant in the row. Autumnal planting ſucceeds beſt; but they will do alſo in the ſpring. Their tops ſhould not be left more than one inch above the ground. When they begin to puſh out their buds in the ſpring, a careful perſon ſhould be made to go along each row, rubbing off with his thumb every bud he ſees, except one, which in this caſe will ſoon puſh up to be a vigorous ſtem, without collateral ſuckers to weaken it. This operation, if carefully performed, will not only make much better plants than otherwiſe could have been obtained, but it will ſave a great deal of expence that muſt have been incurred, had it been neglected.

Nothing more is wanted but to keep the ground clean between the plants, and to dig it over between the rows, at leaſt

once a year; for the ground for this plant cannot be kept too rich and tender. If justice has been done to it in all respects, the plants, in general, will reach to about four feet in height the first season; and in two years more, or at the most three, they will be large enough for planting out where the fence is meant to be.

Rich arable or meadow land is that for which this fence is the best adapted; and as this plant requires to be planted on the flat surface, without any ditch, and can never have the ground on which it is to grow too rich, it will be adviseable, in general, to plough up a narrow ridge where the hedges are meant to be planted, so early as to admit of its being four times, at the least, ploughed, before the time for sowing of turnips. Let it be very richly dunged, and put into turnips, in drills about sixteen inches apart, and properly hoed; after these are drawn, the ground may be either ploughed or dug, and harrowed smooth, to prepare it for being planted.

The ground being thus prepared, let the

the plants (which will now be from 10 to 12 feet high, and from one inch, to an inch and an half diameter at the root) be taken up from the nurfery, and carefully forted, fo as to be all nearly of the fame fize, which are to be planted together. Let a mark be then made in the middle of the ridge, where the centre of the hedge is to be, and ftretch a garden line, parallel to that, nine inches from the centre; then let one man with a fpade begin to open a hole on the outer fide of the line, fufficient to receive the roots of one plant, and let an affiftant put the plant into that hole, flanting the top of the plants to an angle of about 45 degrees to the horizon. But, inftead of laying thefe parallel to the line, let them flant fo much inwards, as that every plant, at the height of four feet above the furface of the ground, fhall be right above the centre of the ridge, and proceeding in that manner, leaving an interval of about one foot, or fifteen inches, between each plant, go round the whole of the inclofure. When this is finifhed, move the line to the fame diftance (nine inches) from the middle of the ridge,

on the oppofite fide; begin, and proceed exactly after the fame manner, to plant another row of poplars, in a direction the reverfe from that of the former, fo that if the tops of the one row lie to the eaftward, inclining to the left hand when you look eaftward, the tops of the other fhall lie weftward, inclining to the right hand, if you ftill look eaftward; fo that the two rows meet each other, at the height of four feet from the ground, exactly above the middle of the ridge. The whole row being thus planted, let the tops of both rows be plaited through each other, fo as to affume a horizontal pofition, like the top of a rail; and the fence, when viewed fideways, will have fomewhat of a lozenge-like appearance, but not croffed like the willow fence; but with this difference, that the ftems are much thicker and ftronger in every refpect, and that they are not contiguous to each other, and cannot be wattled through each other, unlefs at the top only. This, then, forms at the very firft moment after it is finifhed, a fort of living railing, of no inconfiderable ftrength, which, even in this ftate, will be a tolerable fence, and which

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in the courſe of a few months, will riſe to five or ſix feet in height, ſo as to be an effectual ſcreen againſt the ſeverity of the weather, and which in the ſpace of a few years, under judicious management, will have acquired ſo much ſtrength as to be nearly impenetrable by animals of any ſort.

In this way may be reared a hedge that will be a perfect defence againſt all the larger-ſized animals, man only excepted; but, if it be intended to guard againſt the intruſion of boys, or ſmaller animals, the following precautions muſt be adopted:

When the hedge has been completed in the manner above deſcribed, let the earth at the roots of the plants be ſmoothed, and plant a young ſweet-brier plant in the opening left between each two of the poplars, ſo that there ſhall be the ſame number of plants of eglantine, as of poplars; but let theſe eglantine plants be put about three inches farther back than the line of poplars, ſo that they may be about twelve inches diſtant the one row from the other. Theſe plants ſhould be of one

year old, or two at the moſt, for as it grows very quickly, it will ſoon reach the top of the hedge.

The firſt ſummer after planting, nothing more is neceſſary than to keep the bottom of the hedge free from weeds; and in the autumn, go over both ſides, cutting away with hedge-ſheers, all the ſhoots that come beyond the line of the ribs of the hedge, as the original ſtems may be called; then raking that rubbiſh back from the hedge, cut over with the point of the ſheers, every plant of eglantine cloſe by the ground, leaving the dead ſtems that are between the ribs of the hedge, without diſturbing them. Next ſeaſon, the eglantine will ſend out ſtrong ſhoots from the bottom, which puſhing through the dead branches of the former year's growth, will intermingle with them, and fix them firmly in their place, ſome of theſe ſtems alſo puſhing through among the ribs outwards. In the autumn, once more, cut the ſides with the ſheers as before; and then, once more, alſo cut over the eglantine at the bottom, as in the former year. The matting of prickly-brier,

in

in the heart of the hedge, will now have become very cloſe, ſo as nearly to fill up the whole of the internal cavity orginally left between the ribs; and the next year's ſhoots intermingling with theſe, will render it ſtill cloſer. The ſides of the hedge ſhould be clipped every year, and the eglantines cut over as above deſcribed, until the whole of the bottom part of the inſide of the hedge ſhall become as cloſe as you wiſh it to be, ſo as not to ſuffer a fowl, or any animal of that ſize, to be able to creep through it; after which time it will be only neceſſary to cut the *ſides* of the hedge annually, ſo as to give it an external coating of living eglantine, which will form a fence the moſt impenetrable, as well as the moſt beautiful, that can be conceived. To add to the beauty, a few plants of honeyſuckle may be planted along the hedge, and ſome of the freeſt ſhooting roſes, particularly the white roſe, interſperſed through it, which will thrive abundantly.

The ſhoots on the top of the hedge may be allowed to run upwards, till they have acquired the ſize you wiſh for, or have

have attained to as great a height as you would incline; when they may be cut over, at four feet from the ground, and applied to the purposes you find most useful, or for fire-wood, of which they will afford a very great quantity. After being thus cut over, they will send forth shoots, in general, which will reach to nearly five feet high in one season, and about the thickness of a man's thumb at the under part. In three years, they will be as thick as the wrist, and very tall.

This kind of fence, I have actually reared, and I can safely recommend it as the cheapest, the most quickly reared, the strongest, the most beautiful, the most durable, and in all respects the best kind of fence for rich land, I have ever seen; and I consider myself as fortunate, in having stumbled upon a thing, which for more than forty years I had considered as a desideratum in agriculture, that I never hoped to see supplied, viz. a fence which for the expence of two-pence the yard, at the very highest estimate, can be made so as to be nearly sufficient as soon as it is done up; which can be kept in complete repair ever afterwards,

afterwards, without any expence (for the loppings, in every ſituation, will be worth more than the expence of pruning them); and which will far outlaſt the greateſt period of human life; being a complete defence, at the ſame time, againſt the ſtrongeſt, as well as almoſt the ſmalleſt noxious animals of every ſort.

The intelligent reader will eaſily perceive why the ribs were made wider at the bottom than above; for in this way alone, could the ſides of the hedge be kept alive and cloſe the whole way of the bottom.

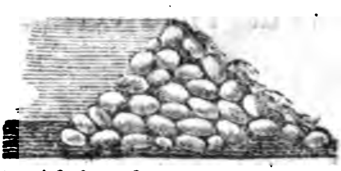
I need not add, that, however adviſeable this kind of fence may be in rich lands, it could not be made to thrive on a poor ſoil, ſo that it ſhould never be attempted on ſuch land.

For the uſes of the larch-tree in fencing *barren* ground, the reader is referred to the Third Volume of theſe Eſſays.

Of the beſt Method of making Mill-dams, or Wiers, Heads, or Breaſts acroſs Rivers.

I KNOW of no ſpecies of fence upon which more money is generally expended, than that which forms the ſubject of the preſent article; for, though I hope to be able to ſhow that it may be eaſily effected, yet, as it has been hitherto executed, it is not only expenſive on its firſt erection, but is ſo liable ever afterwards to ſuſtain damage from floods, that it is a ſource of never-failing diſquietude, and endleſs charge, to the owners of ſuch works.

Hitherto, it has been cuſtomary to make the dike which forms the mill-dam, head, or wier, which runs acroſs a river, univerſally of a triangular form, being wide at the baſe, and growing gradually narrower towards the top, where it ends in a kind of point, as in the margin, than which



no form can be deviſed, that could be weaker, or more liable to accidents. The force

force of running-water, when its velocity is accelerated by falling from a confiderable height, upon bodies that oppofe its motion, becomes nearly irrefiftible; and, in this mode of conftructing a dam, the artift feems induftrioufly to have aimed at giving an example of the power of water, under thefe circumftances: for no fooner does that water fhoot over the uppermoft ftones of the dam, than it precipitates itfelf with violence upon thofe ftones on the lower fide of the inclined plane, which are made to project beyond the firft—but which are thus made to fuftain the whole force of that concuffion. From one ftone it proceeds to another, and another, ftill acquiring additional velocity, till it reach the bottom of the inclined plane; and, if the height be confiderable, it is eafy to fee that the force of the water, before it reaches the bottom, muft have become fuch, as to be capable of difplacing the largeft ftones that the power of man can place in that pofition*.

* The water too, which rufhes through between the crannies of the ftones every where, efpecially where the mound is of confiderable height, is fo powerful, as to difplace the materials in every part, and greatly accelerate the ruin.

Thus

Thus it has happened, and ever muſt continue to be the caſe, that every weir which is conſtructed on this principle of rough unhewen ſtone, is, from time to time, liable to be ſwept entirely away, ſo as to lay the machinery waſte until it be again rebuilt; which frequently happens at that ſeaſon of the year, when ſuch operations are the moſt troubleſome and expenſive.

The frequent recurrence of ſuch accidents has induced ſome owners of machinery to erect their weirs in a very expenſive manner at firſt, by building the whole triangle of hewn ſtone, the ſurface of which is ſo ſmooth, as to ſuffer the water to glide over it, without being able to inſinuate itſelf ſo readily between the crannies as in the former caſe. Much good likewiſe, ſome are inclined to think, may be derived from giving the ſurface of the weir a particular form of curvature, which I do not think neceſſary here to dwell upon. This is, indeed, found to give it ſome additional ſecurity; but, unleſs the whole be batted together with bats of iron, it is ſtill found to be inſecure; and the expence,

where

where ſuch batting is attempted, is ſuch as to prevent it from being carried into effect, unleſs under very particular circumſtances.

Fortunately, however, for thoſe who have works of this kind to accompliſh, by adopting a more judicious mode of conſtruction, they may rear a dam that will be equally ſtrong with the inclined plane, when made of *hewn ſtone, or even when batted with iron,* at an expence not greater, at leaſt, than would have reared one, of the rudeſt conſtruction, of common ſtones.

The reader, from what has been already ſaid, will eaſily perceive, that the chief circumſtances which are wanted to give ſtability to the dam, are, to remove the ſtones out of the way of the falling water, ſo as to free them from running a riſk of being diſplaced by it in its fall, and to prevent the water from being forced violently through the crevices of the mound towards the bottom; he will alſo perceive, that the firſt part will be eaſily effected, merely by making that ſide of the breaſt which looks towards the lower part of the river, a perpendicular wall, inſtead of an inclined plane —for in this caſe the water, when it is

forced

forced over the top of the dam, with the velocity it neceſſarily acquires when in a flood, will ſhoot over clear, without touching any part of the perpendicular wall, exactly in the ſame manner as it ſhoots over a perpendicular rock, in a natural caſcade. This is ſo obvious, as to need only to be ſtated, in order to be recognized as unexceptionably juſt, by every perſon who ſhall beſtow a ſingle thought upon the ſubject. It is indeed ſo obvious, that it muſt excite ſome degree of wonder, it ſhould not have been long ago carried into univerſal practice.

It is not, however, a matter of great difficulty to account for the manner in which mankind have been led into a general perſuaſion, not only of the *utility* of the triangular form of a double inclined plane, but even of the *neceſſity* of it, for giving ſtrength to the dam dike. It is very obvious, that if a ſtrong force were applied to one ſide of a perpendicular wall, tending to puſh it over, that wall would receive a great additional ſupport, were a ſtrong beam of wood placed in a diagonal direction upon the ſide of the wall, oppoſite to that to which the preſſure

preſſure was applied—it is exactly upon this principle that the buttreſs of ſtones, thus applied, has been ſuppoſed to ſtrengthen the dam dike—for as the water, flowing forward, apparently tends to force the wall forward along with it, the buttreſs ſeemed to be neceſſary, to enable it to bear that preſſure, without being carried away along with it.

But here it deſerves to be remarked, that there is a great fallacy in this mode of reaſoning, as applied to this caſe. The ſtrength of a wall for reſiſting the force of water, depends chiefly upon the abſolute weight of the materials of which it conſiſts; and if theſe materials are of ſuch a form as to make the water preſs perpendicularly on any part of it, the very weight of that water, if the materials reſiſt the entrance of water, will add ſomething to its ſolidity. Now, as there is nothing to prevent you from adding as much thickneſs to the wall, as the circumſtances of the caſe ſhall render neceſſary, the buttreſs on the *under* ſide may be removed, without the ſmalleſt danger of rendering it weaker in any reſpect;—and, for the reaſons already given, it ought moſt certainly to be removed.

There is not, however, the ſame reaſon for removing the ſlope on the upper ſide of the wall; on the contrary, the farther it is filled up above the breaſt, and the more gradually it ſhelves downward there, the firmer it will be: for, as the water preſſes with a force exactly proportioned to its perpendicular depth, if the mound be broad enough, at the bottom, where the preſſure is, of neceſſity, greateſt, there is no neceſſity of having it broad at the top, where that preſſure is diminiſhed almoſt to nothing. The eaſineſs of the ſlope, too, is well adapted for preventing the current from ſtriking with great force upon it; or other objects which may be forced down with the ſtream, from laying violent hold of it, and tearing it forcibly aſunder. Nor is it a matter of great difficulty to make ſuch a mound; for, as the water above the dam is nearly ſtagnant, any kind of looſe ſtones, or gravel, or other rubbiſh that is not ſoluble in water, will be in no danger of being diſplaced by the ſtream, but will lie there undiſturbed, if they be thrown in any-how, at random.

Theſe principles being thus explained, I ſhall

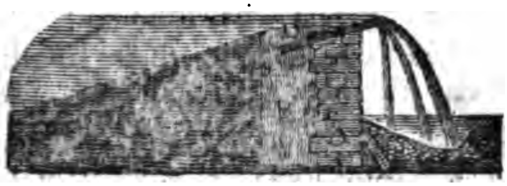
I shall subjoin a few brief directions for constructing bulwarks of this sort, which, if carefully adverted to, will seldom fail to give satisfaction to those who shall adopt them.

It needs scarcely be observed, that in building this kind of wall, as in every other wall whatever, it is necessary to dig, till a firm foundation be found.—Rock is the best, where it can be reached, for obvious reasons. Where the bottom is only gravel, a wide trench should be made, for a considerable depth, which ought to be, at least, six or eight feet in width. All the rubbish that comes from this trench should be thrown to the *upper* side of the dam. The wall should then be built, two, three, or four feet in thickness, as circumstances shall indicate; the higher the dam, the thicker, always, should the wall be. But few cases occur, in which more than two or three feet are absolutely necessary. The stones in this wall should be bedded with as great care as possible, without any mortar, or with tarras at the bottom, especially if any mortar be used, and as few little pinnings be put in among them as may be.

And, as it is of great consequence for preventing the waste of water, but still more, for rendering the wall firm and durable, that no water should leak through the dam, the opening that is left on the *upper* side of the wall (which, in no case, should be less than three feet, and, where the mound is high, five or six feet will be better) should be rammed full of clay, regularly as the wall rises upwards. When the wall reaches near to the height that is required, it ought to be brought to a true level across the river, its whole length, and upon the top should be laid a coping of flat stones of as large a breadth as they can be got, and neatly cut, and closely joined in every part (where this cannot be had, or where it is required to project very far, planks of oak-wood may be adopted in its stead). This coping of flat stones should project over the perpendicular-wall, on the under side, as far as the nature of the materials will allow; and on the other side, it ought to extend as far as the length of the stones will permit, being so laid as to slope downwards, towards the upper part of the river, in such a man-

ner as that the dipping edge of theſe ſtones ſhould be from ſix to twelve inches (according to their length) lower than the edge which projects over the wall. Theſe ſtones in the dipping lip ought to reſt upon the bed of rammed clay, which ſhould riſe higher than their lower lip, and overlap it in part, and if the flat ſtones cannot be made to join ſo cloſe as to be water-tight—ſome clay ought to be laid below them, ſo as to prevent the water from ſinking down through the wall, which is always attended with danger. Small ſtones may ſafely be rammed into that clay, and it ought to be covered with gravel, which ſhould riſe nearly, but not quite ſo high as the projecting lip of the coping of the wall. Stones, rubbiſh, or gravel ſhould be then tumbled down careleſsly into the bed of the river *above* the dam, ſo as to fill it up, as far as can be done at a moderate expence, making it to ſhelve gradually downwards from the dike into the water; and it will be adviſeable, where conveniency permits, to have the whole of this bed to be puddled, ſo as to make it carry the water through it without

sinking. The figure annexed represents a section of the whole when finish-



ed, in which A is the wall; B the bed of clay, intermixed with stones rammed firm; C the coping; D the loose stones and gravel covering the whole, and extending forward in the form of an inclined plane beneath the surface of the water in the dam.

By inspecting this figure, the use of the projecting lip of the coping will be apparent. It serves to throw the water clear over, so as to make it fall at some distance from the bottom of the wall. This distance will be greater when the river is in flood than at other times; of course, it will have a tendency to make a cavity in the bed of gravel at some feet distance from the wall, so as to be in no danger of undermining it. But should any danger of this sort be apprehended, a row of flat stones (or, for want of these, a plank of oak) placed along the bottom of the wall, leaning towards it at top—and sloping some inches from it below,

below, the under part of these stones being sunk as deep at least as the foundation of the wall, and then covered up with gravel, will effectually secure it. Though this is rather a superfluous precaution.

I beg leave here to repeat, that great care be taken to make the wall, through its whole length, as true a level as possible, that the sheet of water may be spread over the whole of an equal thickness, during the floods, which will tend to moderate its force very much. I need scarcely add, that in laying out the direction of the wall, it should never be suffered to come so near a rock in front of it as to endanger a powerful eddy being thrown back upon the wall to endanger it—this being obvious to every considerate person. Where the head is thus made perfectly level and smooth, it will often happen that the stream of water which flows over it for the greatest part of the year, will be so thin as not to prevent the growth of aquatic grasses near the top, which ought not to be discouraged—for which reason a little mould among the surface gravel (which ought always to be small) will do no harm.

I am aware of one objection to the mode of making dams here propoſed (which, indeed, affects all the other contrivances in this Volume) viz. that it is ſo ſimple, and ſo little expenſive, as not to be calculated to catch the attention of men, like thoſe vaſt projects which have the *grand* and *wonderful* to recommend them. It propoſes only to benefit thoſe who are attentive to their own intereſt and a judicious economy. A time may come, however diſtant, in which theſe may be deemed objects of great national importance.

It will alſo be objected, that the ſtones will be in danger of being *ſucked* out of the wall, ſo as to undermine it, and make it tumble down; this being an accident to which breaſts on the modes of conſtruction now in uſe are extremely liable. It becomes, therefore, neceſſary that the reader ſhould be here directed to attend to the circumſtances which have been here adopted with a view to obviate this evil, that the ſtructure may be ſo carefully erected as to be in no danger of being deficient in theſe reſpects, ſo as to render the work of no value.

In the firſt place, you will pleaſe to ad-

vert

vert to the bed of clay, rammed in upon the upper ſide of the breaſt; care ſhould be taken that the foundation of this clay bed be dug ſo deep as to reach the ſolid bottom—and that the clay *there* be very carefully rammed down, ſo as to leave no paſſage for the water at that place, or anywhere elſe; for if water ſhould force its way through any ſmall crannies towards the bottom, eſpecially where the breaſt is of great height, it will force its way with ſo much impetuoſity as ſoon to widen the breach, and carry every thing before it.—It is chiefly becauſe of the neglecting this precaution, that breaſts for water are in general ſo unſtable. With a view to give mounds of this kind ſtability, it is uſual to throw in a great quantity of *large* ſtones in the place that is here occupied by the clay, than which nothing could be more injudicious—for the water always finds an eaſy paſſage among theſe ſtones—and infallibly muſt *ſuck* out, as it is technically called, the lower part of the mound.—This is the unobſerved cauſe of the ſucking out of walls, as it is called, which has been commonly aſcribed to the eddy from below.—We ſhall ſoon

have

have occaſion to take notice of other benefits that are to be derived from this bed of clay.

In the ſecond place, the levelneſs of the top of the breaſt is of great conſequence for giving ſtability to the work; for by this means the ſheet of water, by being extended equally to a great length, is extremely thin in every part, and, conſequently, its force is much leſs conſiderable than when it is deeper in one place than in another; where powerful ſtreams are formed, which dig out pits below, that are extremely troubleſome and dangerous. This circumſtance ought therefore to be attended to with great care.—For the ſame reaſon, the longer the breaſt is, the ſafer it will be, where this circumſtance is adverted to.

Thirdly, the coping at top ought to project as far over the wall as poſſible, and to be cut quite even in the edge.—By this means, the water is made to ſhoot clear over the breaſt ſo as never to touch it, and is of an equal thickneſs in every part. This is a contrivance that has never yet, that I have ſeen, been introduced into practice, and from the want of it, much miſchief is produced.—

For,

For, where this is wanting, the water in its fall ſtriking on one ſtone after another, with the accelerated velocity it acquires in its deſcent, ſoon inſinuates itſelf among the ſeams—ſucks out the ſmaller ſtones, and thus throws down the whole fabric.—The cauſe being thus removed, the effect, of courſe, will not be felt.

Fourthly, in conſequence of the ſhoot that the water acquires, the place where it falls at the bottom will vary with the force of the current.—When the ſtream is low, the water will fall almoſt perpendicularly down: when higher, it will ſhoot over to a greater diſtance; and when it is in a flood it will force itſelf over to a ſtill greater diſtance.—But when the water falls down perpendicularly, it has ſo little force as not to be able to derange any thing—when higher, it acquires more force, and puſhes more forward—and when in a high flood, it puſhes forward with the greateſt impetuoſity, and falls at a diſtance from the breaſt proportioned to the quantity of the water, and the height of the fall.—It is, of courſe, at the place it now reaches, that it digs the deepeſt pit,—Hence, then, it would follow, that ſhould

ſhould the water, when it ſhoots over the head, alight upon a bed of gravel, it would work for itſelf a pit, not cloſe by the wall, but at ſome diſtance from it; and that diſtance would be the greater, the higher the head from whence the water falls, ſo as to form the bottom of the pool, ſhelving upward, to the wall, as in the figure;—thus the foundation of the wall would be in no danger of being undermined.

But ſhould any danger of that kind be apprehended, where the fall is great, and the bottom ſoft (a bed of clay, for example) it may be adviſeable rather to prepare a proper baſon for the water, than to leave it for nature to form one for herſelf. With that view, let the bottom be ſcooped out, as in the figure, ſo as to make a deep pool, into which the caſcade may fall. The depth of this baſon may be augmented, by raiſing a kind of bank of gravel or looſe ſtones before it. In this way all danger of undermining the foundation will be avoided; the force of the fall being broken by the water, before it reaches the bottom. If the bottom be very ſoft, a little gravel may be thrown into it, to defend it; no

kind of ſhoeing, where the pool is deep enough, can be required.

There is only one caſe I know of, where the wall runs a riſk of being hurt by the water, after it has made its ſhoot, viz. when the falling ſtream ſtrikes upon a ſhelving rock which inclines towards the wall, ſo as to drive an eddy back upon it, or make it wheel round in an irregular kind of current. The eaſieſt cure in this caſe, will be to dig out the rock where it is ſo circumſtanced, and to form a deep pool in its place—the materials taken away can always be uſefully employed in making the *head*. But if, after all, any danger ſhould be apprehended, from any kind of eddy below ſucking out the ſtones, that may be very eaſily and effectually prevented, by laying a few planks of oak along the whole length of the lower part of the wall, on whoſe ſmooth ſurface the water can take no hold, and behind which the ſtones will be effectually ſecured. I need hardly obſerve, that where any thing of this ſort is intended, care ſhould be taken to put ſome knots of oak into the wall, at proper places, when it is built, for the purpoſe of ſecuring theſe planks.

Neither

Neither is it neceſſary for me to enlarge upon the neceſſity of augmenting the thickneſs of the breaſt wall, where that is required to be made of an unuſual height---that being a thing ſo ſelf-evident, as to be underſtood by every ordinary mechanic. It may not, however, be improper to remark, that a wall which is ſtrong enough to ſupport the ſame quantity of looſe materials as the mound conſiſts of, that lies on one ſide of it, is all that is required. This is neceſſary---but no perſon of ſound judgment will chooſe to go to the very limits of poſſibility in a caſe of this ſort---it is always ſafeſt to err on the ſide of exceſs, ſo that the wall ſhould be made ſo ſtrong as to remove all doubt.

On the Means of preventing the Sea from making Encroachments on the Land.

WHEREVER water is in motion, it is perpetually producing changes on the ſurface of this globe, which at times prove highly beneficial to individuals; but more frequently hurtful, ſeeing the ravages produced

duced by that element, which, when directly opposed, is found to be often irresistible, are frightfully destructive. In the preceding pages, some directions, which have never been found to fail in any one instance where they have been followed, have been given, for securing the banks of *rivers* from the devastations by running waters. I now propose to add a few hints concerning the most efficacious means of setting bounds to the raging fury of the *ocean*.

The principle upon which the force of water can be effectually resisted, is precisely the same in all cases: so that, in strict propriety, little can be added to what has been already said, farther than to show in what manner the same principle can be so managed, as to apply, with the best effect, to the different cases, as they shall occur.

That water, when strongly agitated, can best be resisted by gently yielding to its influence, and not directly by opposing its impulse, is a truth that cannot be denied, and never ought to be lost sight of in every operation, in which that powerful agent is concerned. In conformity with this principle, it is found, that where the sea-beach

is low, the land is rather, in general, encroaching on the sea than the reverse--- but wherever the shore is steep, the sea is making encroachments upon the land, which are more or less considerable, according to circumstances. Where rocks oppose an impenetrable barrier, they are little altered for ages; for, although immense masses of rock are sometimes overturned by the raging fury of the ocean, the progress it makes in such cases is so slow, as scarcely to be perceptible; but wherever the sea approaches a perpendicular cliff of clay, or penetrable mould, it encroaches with hasty strides; and sometimes carries off whole fields of good land, by the devouring sweep of one furious tide.

To guard against this evil, several contrivances have been adopted, most of which have been so expensive and inefficacious, as to compel those who are sufferers by this misfortune, to be often obliged to remain inactive spectators of the ravages to which they are incessantly exposed. The general mode that has hitherto been attempted to stop the progress of this evil is, to erect a strong bulwark of large stones *in front of the bank,*

bank, piling theſe ſtones above one another as carefully as poſſible, ſo as that the front expoſed to the ſea, ſlopes gradually backward towards the bank above, to which it finally joins, at ſuch a height above the ſea as the undertakers are able or willing to make it.

Every bulwark of this kind is liable to be deſtroyed by one or other of the following circumſtances, all of which, on ſome occaſions, co-operate, ſo as to get it thrown down, nearly in as ſhort a time as was required to rear it up: 1ſt, If an individual has only a ſhare in the property of ſuch a bank, and thoſe on either ſide of him neglect to fortify their property, the ſea, making encroachments at either end, leaves his bulwark *there* expoſed to the fury of the elements, ſo as to ſtand in need of perpetual repairs; or, 2d, Although this evil ſhould be avoided, the ſea, when furiouſly impelled by a ſtorm, is forced up the inclined plane with great fury, and, when the wave falls back, the body of water that had been forced up, ruſhes back again over the ſtones of the inclined plane, with ſtill greater force, like a caſcade, ſo as forcibly to tear the ſtones out of their places, exactly

in the ſame manner that the ſtones of a mill-dam, of the uſual conſtruction, are diſplaced; or, *laſtly*, the water, in its return, inſinuates itſelf between the ſtones and the bank at the top, where the ſtones join to the earth, and there ſcoops out the earth, ſo as to leave the ſtones defenceleſs from behind, and thus expoſed to be tumbled headlong down, by the force of the caſcade, occaſioned by the revulſion of the tide. Nor is it poſſible that this evil ſhould ever be obviated, unleſs the inclined plane of ſtones ſhould be carried to a greater height than the water can ever be forced to riſe, by the accumulated force of a high tide, impelled by a ſtorm; a thing that, if it could be accompliſhed by human power, would fruſtrate its own aim---for the caſcade would thus become ſo much lengthened, as to give the revulſing tide an irreſiſtible power over the ſtones toward the bottom, that muſt tear them from their places in a ſhort time, and ſcatter them about like pebbles on the ſea ſhore. Thus would reaſon decide on the probable conſequences of attempting to ſecure property, by means of ſuch bulwarks; and experience has fatally confirmed the juſtneſs

of it, by the example of numberleſs individuals who have had the misfortune to attempt it.

Wherever a cure is practicable, it muſt be effected by a procedure, in almoſt every reſpect, the reverſe of the above. Large ſtones, inſtead of being gathered together there, muſt be carefully removed from the beach; for wherever a large ſtone is ſuffered to remain near the ſea-ſhore, between wet and dry, as it may be called, it infallibly produces a whirling eddy, which prevents the ſand and gravel from ever attaining that ſmoothneſs of ſurface which alone can mitigate the fury of the waves, and prevent them from ſcooping out the earth near the ſea-ſhore. Thus it happens, that wherever many large ſtones are permitted to remain near the ſhore, the ſand and ſmall gravel, inſtead of being ſuffered there to remain till it be accumulated into a ſolid bed, that gradually riſes above the level of the ſea, is whirled about by an uninterrupted agitation, among the ſtones, till it, at laſt, makes its eſcape from among them, and is ſuffered to remain at reſt, on ſome leſs perturbed part of the ſhore, and

there to form a bulwark to protect that place from farther encroachments; whereas, that part of the shore where the great stones are suffered to remain, must continue nearly at the same depth, for ages, and suffer the defenceless coast, behind it, to be infallibly exposed to the encroachments of the sea, until that nuisance shall first be removed. By adverting to this circumstance, and carefully attending to the natural operations of the sea, in cases of this sort, we shall be enabled gradually to perceive by what steps the evil complained of may best be guarded against.

When the sea washes down a great body of clay, or other kind of earth that is easily diffusible in water, the whole of that diffusible earth is quickly mixed with the agitated water, and with it is carried far away, until it reaches some place where the water is suffered to remain so long at rest as slowly to allow it to subside. There it forms beds of that soft kind of mud, called fleetch, which, when they gradually rise above the surface of ordinary tides, become, in time, covered with herbage, and, at last, form those rich grass

lands,

lands, known by the name of *falt-marshes*. While this operation is going forward, the fand, gravel, and ftones, which were intermixed among the earth, in its original ftate, being more weighty than the other component parts of the mould, are depofited near the bottom of the bank from whence they originally came; and if thefe materials be abundant, and few large ftones among them, the bed of fand or gravel thus accumulated, rifes, in time, above the furface of the fea, and forms that kind of natural fea-beach, which is found along the fhore, in moft places, where no fenfible encroachments of the fea are perceptible. But if little fand or gravel be contained in the bed of earth that is wafhed by the fea, efpecially if that bed of diffufible earth reaches deeper than the furface of the water, the quantity of gravel or fand is too fmall to fill up the void that is occafioned by the wafhing of the fea, and the water continues deep *to the very edge of the bank*. Where this happens to take place, it is a very hopelefs cafe; and it will be found a matter of great difficulty to effectuate a radical cure—but, fortunately, this is a cafe

that very ſeldom occurs; ſo ſeldom, indeed, that I have never ſeen one of the kind. In general, there is ſuch a quantity of ſand or gravel accumulated at the bottom of the bank, as to raiſe the beach there above the ſurface of low-water mark, —frequently above the ſurface of high-water mark, neap-tides; ſo that it is only at *ſpring tides*, or during ſtorms, that damage is ſuſtained. Where this is the caſe, the evil may be obviated, in moſt caſes, at a very ſmall expence; and, in no caſe, will the expence be extravagantly high, if the following mode of procedure be adopted:

Let a trench be firſt opened in the ſand or gravel, ten, twelve, or twenty feet wide, running in a direction perpendicular to the ſhore, right into the ſea. This ditch ſhould not go deeper than the ſand or gravel, nor need it be made more than one foot in depth, unleſs as afterwards excepted, let the gravel be of what depth it may. This trench may be carried out farther or ſhorter as circumſtances ſhall indicate. As ſoon as the trench is made, fill it up with earth dug from the bank immediately behind it, taking care to pick out the large ſtones that happen

happen to be among it. Lay this earth so as to slope gradually upward towards the land, rising in a regular slope, with an angle between 10 and 20 degrees from the horizon, continuing the slope in this manner till the top rises higher than the highest rise of tide when agitated by a storm. When this trench has been thus filled up with the earth, taken from the bank—open a fresh trench, of the same breadth, at one side of it, in the gravel, covering the surface of the earth that has just been laid down, with the gravel that is taken out of the trench, so as to cover that new-laid earth with a bed of gravel about one foot deep over the whole. Let the second trench be filled up and covered in the same manner, and so on, till the whole be finished.

If the bank of earth be not very high, and the shore over which the tide flows does not dip much, the inclined plane may be pushed so far forward into the sea, as to consume the whole of the earth that must be taken from the bank, to bring it to a regular slope to its full height. The advantages to be reaped from this mode of procedure, will be, 1st, That the earth will thus

be removed at the leaſt expence poſſible—2d, That the gravel will require to be moved to a ſmaller diſtance, for covering it, than would otherwiſe be required; and, laſtly, that no ground will be loſt, but rather ſomething will be gained from the ſea.

But where the ſhore dips very faſt from the beach, it may perhaps be impoſſible to proceed after this manner, ſo that the ſlope muſt be made chiefly backwards upon the the land; and in that caſe it will be neceſſary to dig the trench as deep in the gravel near the ſhore as can be conveniently done, in order that a quantity of gravel may be thus obtained to cover the earth as far back within land as poſſible.

Pleaſe, however, to obſerve, that the new-made earth will gradually ſubſide, and that the part of the ſlope which is continued back *upon the ſolid ground*, will not ſubſide at all; ſo that if no precautions were adopted, there would ſoon happen to be a breach at this place, which would render the bank vulnerable.---To guard againſt this evil, therefore, be careful to ram the new-laid earth as firmly down as poſſible, eſpecially near the joining; and alſo

alſo to trench over the ſurface of the ſolid bank to a conſiderable depth under the ſlope, which will allow the earth there to to ſubſide a little, ſo as to keep them from ſeparating.

The gravel ought to be carried up the ſlope as far at leaſt as high water mark during the higheſt tides. Above that, the ſlope ſhould be covered with a ſurface of vegetable mould, of as rich a quality as can conveniently be obtained, laid ſmooth, and ſown with graſs ſeeds---ſo as to bring it to a ſward as quickly as poſſible. Over that ſhould be laid, for ſome diſtance, a little gravel, which ſhould become gradually thinner, as it riſes higher, till it decreaſes to nothing. When this bank has become covered with a cloſe pile of graſs, ſuch waves as may be accidentally puſhed to an unuſual height during a caſual ſtorm, will flow back over its ſmooth ſurface without breaking it. For obvious reaſons, no ſtones or other impediments ought to be ſuffered to remain upon the ſurface of this part of the bank.

It will be unneceſſary for me to give more detailed directions, concerning the variations that ought to be adopted as circum-

ſtances

ſtances differ, ſeeing that common ſenſe, where the principle is well underſtood, will ſuggeſt all that is neceſſary to every attentive mind which contemplates the ſubject; and even if a volume were written upon it, there is little probability that all the variations of circumſtances, which in ſome caſes may poſſibly occur, would be adverted to. I ſhall therefore add no more than barely to ſuggeſt, that if the quantity of earth which requires to be taken away, be more than can be ſwallowed up in making the ſlope, perhaps the eaſieſt way of diſpoſing of it, after the ſlope is completed, will be to wheel or cart it down the ſlope at low water, as far as can be done, and there to throw it down looſe, to be waſhed away by the returning tide---taking ſpecial care, in this caſe, to remove any ſtones that may be left---and not to allow a high mound there to accumulate.—If the bank be ſo very high, as to render it an object of great expence to carry the ſlope as far as the top of the bank, in that caſe the ſlope may be diſcontinued, when it has advanced ſo far as to be beyond the reach of the ſea at the higheſt tides.---For, under theſe cir-

cumſtances,

cumſtances, though a part of the cliff may at times fall down merely from the effects of the weather upon it, yet the ſea will not there make any farther encroachments upon the land.

In Holland, where the ſea dikes conſiſt almoſt wholly of looſe ſand, which is nearly in as great danger of being deranged by wind as by water, and where the ſmalleſt accident happening to them would prove fatal to many thouſand perſons, and entirely deſtructive of their property, they are under the neceſſity of adopting precautions for ſecuring their banks that our ſituation renders, in general, unneceſſary. In the moſt vulnerable places, they find the beſt defence they can adopt againſt the alternate attacks of the two elements, is to cover the ſlope of the bank with thatch, which is pinned down along their whole ſurface with care, in a manner that experience has taught them to be tolerably ſecure; but, as this thatch is liable to be deranged by various accidents, magazines of it are laid in at convenient diſtances, and men are appointed to examine the banks daily, along their whole length, each being charged to take

take care, that any derangement in his own division be immediately put to rights. I mention this, here, as a thing that ought to be generally known in this island, though it can ſcarcely ever be required in the caſes of which I now treat---it is chiefly where wiers are attempted with a view to gain land from the ſea, as in Holland, that it can be wanted.

Curſory Hints on the moſt beneficial Method of recovering low Land, in certain Caſes, from the Sea.

ON the ſubject of gaining land from the ſea, ſo nearly connected with that I have juſt conſidered—but upon which I do not mean to enter at large in this place, I ſhall beg leave to ſuggeſt a ſingle hint for farther conſideration.—It is this: land is ſometimes gained from the ſea, by gradually riſing in its ſurface till it be above the level of high water mark—ſometimes by riſing no higher than low water—and ſometimes by making an incloſure, and pumping the water out from

a depth below the lowest tide level, as in some parts of Holland.

In this country, in general, the greatest efforts that are made, have been to recover land that has risen above low water level, but has not reached to the height of high water mark, as in those large works in Bedford, Cambridge, and Lincoln-shires, in which the ground is so low as to be much incommoded by water—and, according to the mode of procedure that has been adopted, it seems to be in no train of ever being better, but perhaps rather worse, if the same system should continue to be followed.

To obtain ideas on this subject, it is necessary to advert, that the extensive marshes here named have been produced by a gradual deposition of mud, continued for ages, which has been carried down by the large rivers which there disembogue into the sea: for the current of these rivers being there met by the sea, occasioned a stagnation of the muddy waters during the full tide, which, while in a state of rest, deposited its mud, and flowed off at ebb-tide much purer than before. The bottom thus gradually rose higher till it got above

the

the level of low water, in which ſtate a few aquatic plants ſprung up, and formed thoſe marſh-lands, which naturally attracted the cupidity of men of property around them; and it became an object of great enterpriſe, ſo to ſhut out the water from theſe marſhes, as to augment their produce as much as poſſible.

Perhaps ſomething was gained in point of *time*, by thoſe operations that have been there carried on---but I much ſuſpect, that, if the ultimate value of the ſubject be conſidered, and the expence at which the alterations that have been made, is adverted to, the loſs has conſiderably exceeded the gain. Nature in her progreſs, though perhaps a little too ſlow for the wiſhes of man, would have effected her purpoſe much more completely (and probably by this time it might have been fully effected) than ever can be achieved by the feeble operations of man. Experience has diſcovered, that certain places in thoſe marſhes are much deeper than others; and, conſequently, by being below the general level, are of ſcarcely any value; nor have they any proſpect of ever becoming more valuable than they now are.---If

nature

nature had been ſuffered to purſue her own courſe, this would not have been the caſe. When the riſing tide puſhes back the muddy waters, theſe, when ſtagnant, muſt aſſume a level ſurface; of courſe, the quantity of matter depoſited at the bottom, during ſtill water, muſt be in proportion to the height of the water above it every where. Hence, where the height of the bottom was within three feet of the ſurface, if the depoſition there was one inch in a given time, where the depth of water was ſix feet, two inches of mud would be depoſited, and three inches where it was nine feet deep. In this way, it is obvious, that the hollow places muſt have been filled up much more quickly than the ſhallows. But when it is farther adverted to, that the water would have remained ſtagnant above the deep places many hours at each tide, while not one drop was above the higher places, it muſt be evident, that the depoſition of mud in the hollows, muſt have exceeded that on the heights, in a ratio much greater than that which is above indicated. In this manner, nature had a perpetual and invariable tendency to level the ſurface of this

bottom,

bottom, and gradually to raiſe every part of it above the ſurface of the water nearly in an equal degree, ſo that every part of the field muſt have been, at laſt, nearly of the ſame value. Many millions of acres, the moſt fertile on the globe, have thus been raiſed out of water; and immenſe marſhes have thus been filled up, which the weakneſs of man alone has prevented him from effecting.

The operations of man, have, in this inſtance, effectually deranged this beautiful economy of nature. Cuts have been made, through which the rivers were to be conveyed to the ſea, without being ſuffered to ſpread, at any time, upon the marſhes. What are the natural conſequences of theſe operations? In the parts of thoſe artificial channels, where the water is made to ſtagnate by the tide, a conſiderable depoſition of mud is made, which tends gradually to raiſe the bottom of thoſe rivers, the loweſt of which were originally intended to operate, and did in fact operate, as drains to the adjoining fields, and to make it higher than theſe fields, and thus for a ſhort while only anſwer the purpoſe for which they were

were originally intended. Now, although the current where the rivers are confiderable, does tend to fweep away part of that mud, at the retreat of the tide, yet a great part of it remains, and this muft either be fcooped out, at a great expence, or the land be deftroyed by hurtful water.

In the mean while, all that mud which is carried forward, paft the marfhes, by the rapid current of the rivers, now confined to a narrow bed, is repelled by the tide, when it gets paft the mounds, and muft there gradually accumulate, fo as to form a bank beyond the marfhes, which, in time, will rife above the furface, and, if permitted, will rife higher than the prefent low lands, fo as to leave them like pits, that muft be fubjected to a perpetual and heavy charge, to render them good for any thing.

From this plain and obvious reafoning (without entering into the confideration of other particulars, which tend to the fame point) the conclufion above drawn feems to be incontrovertible. From that reafoning, likewife, it follows, that the beft mode of ever rendering thofe fields found land, is to put them under fuch ma-

nagement as to enable the owners to ſuffer the waters, when in flood, and, conſequently, in the muddieſt ſtate poſſible, to have free acceſs to theſe fields when they can ſuſtain leaſt damage from it (eſpecially thoſe that are the deepeſt) and to allow that water to run off, after it has remained ſtagnant for a ſhort while, for the purpoſe of depoſiting its mud. But as the diviſion of property there, will render it impoſſible ever to get ſuch a bold meaſure generally adopted, and as it would require ſtronger mounds, than can, in general, be erected round private property, to render this meaſure locally practicable, it ſeems to me probable, that no effectual remedy can ever be there applied for removing this evil.

In the mean while, the progreſs of nature may be ſeen going regularly forward on the banks of the Humber; the tide, in which eſtuary, puſhes the mud that is ſo copiouſly brought down to it by the Trent, the Ouſe, the Darent, and many other rivers, towards the ſhores every where around it, though with ſome diverſity of

progreſs,

progreſs, according to ſituation and circumſtances, to which it is making continual additions of land, that when it has riſen high enough, is among the moſt valuable which are to be found in the kingdom.

FINIS.

DISQUISITIONS

ON THE

DIFFERENT VARIETIES

OF

WOOL-BEARING ANIMALS, &c.

ADVERTISEMENT.

THIS Essay was written for the Bath Society, and published in the Eighth Volume of their Memoirs, from whence it is re-printed, with considerable Additions.

Diſquiſitions concerning the different Varieties of WOOL-BEARING ANIMALS, *and other Particulars connected with that Subject. Written in the Year* 1794.

IT has been hitherto, in general, believed, that the ſheep is univerſally a wool-bearing animal, and that there is no other creature upon the globe that carries *wool*, in the ſtrict and proper ſenſe of the word, but ſheep alone. But, there is now reaſon to doubt if either of theſe propoſitions be ſtrictly true.

Among other good effects that will reſult from the reſearches of the Society inſtituted for the improvement of Britiſh wool, we have already become acquainted with the nature and diſtinguiſhing peculiarities of a great diverſity of *varieties* of ſheep, and other animals, that were not before known in Europe. It is to that ſource we owe an account of the different varieties or breeds of ſheep, that have been diſcovered in the Ruſſian dominions, by the learned

Dr. Pallas, ſo well known in the Republic of Letters, by his many ingenious Works in Natural Hiſtory, and other branches of Science; a tranſlation of which into Engliſh, was lately publiſhed in London. By the ſame means, we have become now perfectly well acquainted with the Spaniſh ſheep, and its diſtinguiſhable peculiarities; as well as with a great many other varieties of the ſheep from many parts of Aſia, differing from each other in a much greater degree than ever was ſuſpected before, in Europe, was poſſible.

It would take up too much of the time of the Society, were I to enumerate, in detail, the individual varieties that might be ſpecified. I ſhall here only briefly ſtate, that (in as far as I yet know) all of them may be reduced to one or other of the three following claſſes, or the mongrel breeds reſulting from an intermixture with each other, viz.

CLASS FIRST.

WOOL-BEARING SHEEP, *properly ſo called.*

THIS claſs comprehends a great many of the varieties of ſheep found in Britain, and

and throughout the greateſt part of Europe. Sheep referrible to this claſs, are alſo found in Aſiatic Ruſſia, in Africa, at the Cape of Good-Hope, and in various parts of India.

Among moſt of the varieties of this claſs, unleſs where it has been purified by a careful ſelection, continued for many years, there is found intermixed with the wool, in different proportions, a kind of ſhort, opaque, brittle, unelaſtic hair, uſually of a dead white or chalky-colour, which is well known to manufacturers, and is eaſily diſtinguiſhable from other hair. It is known by the name of *ſtitchel*-hair in ſome places. In other places, it is called *kemps*; and, probably, it has many other local names, with which I am unacquainted. This kind of hair does not looſen from the ſkin at the ſame time with the wool, and may thus be, in ſome meaſure, ſeparated from it among ſome of the purer wool-bearing breeds. I have reaſon to believe, though I am not abſolutely certain of the fact, that this kind of hair is peculiar to the ſheep of this claſs, and is not to be found in either of the other two claſſes, unleſs where they participate with this one in a mongrel breed.

CLASS SECOND.

HAIR-BEARING SHEEP,

Whose pile is long in the staple, and of a quality that admits of being employed in many manufactures, nearly for the same purposes as wool.

SHEEP referrible to this class, have been usually confounded with the former, insomuch that they have almost entirely escaped the notice of naturalists and others. The pure breeds of this sort are scarcely any where to be found among *manufacturing* nations; but they are reared, in preference to the wool-bearing sort, among the Russians, and other northern nations, where the skins of sheep, with the fleece on, are used for clothing, as they are found to be much more durable than those which carry wool properly so called. There are, however, a great many varieties among the breeds of sheep in this country, which are mongrels between this class and the former. Here, however, as in most cases where accurate distinctions are wanted, although it seems easy at first sight to distinguish wool from hair, by the crispiness of the former, in con-

ſequence of which, it ſhrinks in length, ſo as to require to be ſtretched out before it can be accurately meaſured, which is not the caſe with hair in general, yet this is found to afford a rule too vague for accurate diſcrimination. The following characteriſtics, may, I think, be ſufficiently accurate to be relied on:

1*ſt*, Wool, like the body-hair of moſt animals, is an annual production, ſpringing from the ſkin of an animal. It conſiſts of a great number of diſtinct filaments, that grow more or leſs cloſe to one another in different breeds; but which ſpring out of the ſkin about the ſame time, like corn from a cultivated field; advance nearly with an equal rapidity, till they have attained their full perfection of growth; they then looſen from the ſkin nearly at the ſame period (when a new crop ſprings up below) and fall off in large parcels, all at once, ſo as to leave the body, at one period, nearly bare, or covered only with a ſhort coat of wool. Hairs, on the other hand, (ſuch of them as are of an annual growth only) looſen from the ſkin ſeparately, and at remote periods from each other, and, unleſs where they are accidentally matted together,

ſo as to entangle the looſe hairs among thoſe that are faſt; they fall off individually one by one, and are ſucceeded by other individual hairs to ſupply their place. And as this proceſs goes on through the greateſt part of the year, the length of the coat of *hair*-bearing animals, if left to themſelves, is not near ſo different, at different ſeaſons of the year, as that of wool-bearing animals.

Hair, indeed, as well as wool, ſeems to part from the animal more freely during the ſpring and earlier part of the ſummer than in the autumn and winter ſeaſon; but as the hairs looſen individually, and fall off ſeparately, and as freſh hairs ſeem to ſpring out to ſupply the place of thoſe which have fallen off the moment they are diſplaced, as takes place with regard to the ſhedding of teeth among young animals, it muſt neceſſarily happen, that the pile, or, as we call it, the fur of ſoft-haired animals, will be thinner, and conſequently leſs abundant, in ſummer than in winter; a fact that has been often remarked in regard to hares, rabbits, and other fur-bearing animals, but which has not, to my knowledge, been hitherto fully adverted to. This has been,

been, in general, attributed to the effect of heat, physically considered; and hence it has been inferred, that all fur-bearing animals would carry a thin coat of fur in hot climates universally; a fact that is clearly contradicted by experience. This phænomenon seems to be connected rather with the revolutions of the seasons, like the incubation of birds, and the springing up of certain plants and flowers, at particular seasons of the year. The fleece appears indeed to be very thin during the warm season, but this is not so much because there are fewer hairs in it, but because many of these hairs are then so short, as to contribute little to the weight of the pile; whereas, in winter, these short hairs have become longer, and thus thicken the pile by growing up among the longer hairs that have adhered to the skin during the whole of the summer season. This hypothesis seems to be strongly confirmed by a fact respecting furs that has not hitherto been much adverted to, which, I have reason to believe, prevails very universally, viz. that if a lock of the hair taken from any

kind

kind of fur, be held by the points, and combed the reverſe way, a much greater proportion of it would always be combed out, than ever happens with regard to any kind of *wool* if treated after the ſame manner. Hence, I am, at preſent, inclined to infer, that this great diverſity in the length of the different filaments in the ſame pile, is a diſtinguiſhing characteriſtic between hair and wool, let the fineneſs of each be what it may. I ſpeak at preſent, however, only hypothetically, for I have not had opportunities ſufficient to obſerve theſe facts to enable me to ſpeak with *certainty*.

2dly, A filament of wool has no determinate proportional thickneſs in its different parts, but is variable in all poſſible proportions. Sometimes, the root-end is thicker than the points; ſometimes, and indeed for the moſt part, in this climate, the points are thicker than the roots; ſometimes, the middle is thicker than either end; ſometimes, it is quite the reverſe; at ſome times, the variation of thickneſs is great, and extremely perceptible; at other times, the filament is of an equal thickneſs

throughout

throughout all its parts. Theſe variations in regard to the thickneſs of the different parts of a filament of wool, have been proved, by experiment, to depend upon the degree of heat or cold that has acted upon the animal at the time the filament was in its ſtate of growth; that part of it which grew during the influence of a continuation of warm weather, being always thicker than that part of it which grew during cold weather; the difference of ſize varying with the difference of temperature, in all proportions, the ſize of the filament continuing the ſame only where the animal has been kept in an equal temperature of heat during the whole period of its growth.

Hairs, on the contrary, ſeem to have always a dèterminate ſhape and relative proportion, under whatever circumſtances they ſhall have been produced—one ſpecies of hairs being of one ſhape and proportion, and another kind of another ſhape. In general (and with no exception, that I know of) the body-hairs of animals are thickeſt at the root, and taper ſenſibly to-

wards

wards the point, which is directly the reverse with all wool of grown sheep in this country *.

By

* I find reason to proceed with great caution in this Disquisition, because I have not had opportunities of observing facts with the necessary precision to enable me to deduce general conclusions with the certainty I wish to do. The observation in the text is just, as far as respects the common breeds of animals that are reared in this country; but since the above was written, I have seen reason to believe, that there is a much greater diversity in this respect, than I suspected at the time that paper was written. Before that time, I had often remarked, that the kind of hair called *kemps*, which grows among the wool of our sheep, is always thicker at the roots than at the points; from whence I naturally inferred, that all kinds of hair that grows up among wool, was always of the same sort. I now find that this is not the case; for the native sheep of Jamaica, which carry a considerable proportion of very fine wool, bear, at the same time, a kind of hair, intermixed among that wool, which is totally different from the *kemps* among our wool, in many respects; in particular, it is *invariably* much thicker at the points; that is to say, coarser, of greater diameter, taking each hair individually, than at the roots. It is also uniformly of a greater length than the wool, so as to cover that wool over the whole body, which is directly the reverse with kemps. Each of these hairs of the Jamaica sheep is marked from the point downwards with transverse rings, of short diameter, that

are

By theſe two criteria, wool may be, in general, diſtinguiſhed from hair, where

are alternately black and white, ſo as to give it very much the external appearance of badger's hair.

I find reaſon, alſo, to be ſatisfied, that the form and external appearance of the hairs of different animals differ greatly from each other. Among thoſe which have fallen under my own obſervation, the hairs of the *muſk* animal (a fine ſkin of which I ſaw in the poſſeſſion of Mr. Forsyth, at Kenſington) is, perhaps, the moſt uncommon I have ſeen. Theſe hairs are ſtiff, and approach, in part, to the nature of quills, though they are much ſofter and more flexible than thoſe of the hedge-hog or porcupine. They draw to a narrow point, and are much thicker at the root. Each hair has the appearance of being a flaccid tube, and is a little twiſted, ſomewhat in a ſpiral form, ſo as to have a ſlight appearance of a rope.

Hairs differ alſo from each other in reſpect to the manner in which they are placed into the ſkin. The moſt beautiful variety of this kind I have ſeen, is that of the great polar or white bear, the hairs of which are placed all over the ſkin in tufts, with bare places between, exactly like the briſtles in a clothes-bruſh. Theſe are placed in rows with the moſt perfect regularity, like cabbages planted with the utmoſt preciſion in a garden, ſo that when the ſkin is folded back, either acroſs the body, or lengthwiſe, or diagonally, the ſkin is diſcovered clear between them, in regular rows. Other variations, I have no doubt, take place in regard this particular, that have never fallen within the ſphere of my obſervation.

they

they are entirely uncompounded, without difficulty. But as all the different varieties of ſheep breed readily with each other, and produce a mongrel race, in which the diſcriminative qualities of the parents are blended together, it neceſſarily follows, that where the mongrel breed is produced between a wool and a hair-bearing race, it will afford a fleece that can neither be diſtinctly characteriſed as hair nor as wool, but will participate of the qualities of both. If this mongrel ſhall mix again with a wool-bearing race, the fleece of the deſcendant will approach nearer to wool; if with a hair-bearing race, nearer to hair; and ſo on, they may be blended *in infinitum*. By this means, the diſtinctive characteriſtics of hair and wool may be, in time, entirely loſt, and fleeces be produced that are neither the one nor the other. This ſeems to be preciſely the caſe with moſt of the breeds of ſheep in Britain at the preſent day; and we muſt go, in ſome meaſure, out of the iſland, to recover the genuine breeds; but which, if attended to, will enable us to account for various phenomena that have puzzled many intelligent men.

The

The moſt uncontaminated breed of wool-bearing ſheep I have as yet met with, is, the Shetland breed; and there the wool riſes ſo entirely from the ſkin, about the beginning of June, as to render the ſhearing of their ſheep unneceſſary. It may be plucked off at that time without occaſioning to the animal the ſmalleſt uneaſineſs, as it will fall off of itſelf, if not taken away; the young fleece ſpringing up beneath it, like a young ſhorn fleece. The ſame phenomenon is obſervable in all the breeds of ſheep in the northern parts of Scotland, where the proper time for ſhearing is always indicated by nature, and muſt be attended to. For although theſe ſheep have got ſuch an intermixture with the hair-bearing race as not to allow it to looſen quite ſo entirely as that of the Shetland breed; yet it is looſened to ſuch a degree, that if the ſheep are ſhorn too ſoon, and before the wool is properly *riſen*, as the phraſe there is, it is difficult to paſs the ſheers through it, and the ſkin is left very bare, the young wool not being yet grown. On the other hand, if that ſhearing be too long delayed, the young wool has grown to ſuch a length as to en-

tangle

tangle the ſheers in it, ſo as to cut off a part of it, which is both troubleſome to the ſheep-ſhearer, and when it is thus ſhorn, the wool is uſeleſs. But when the wool is riſen to its proper ſtate, the ſheers ſlide over the young fleece, and cut off the few remaining hairs of the old fleece with the utmoſt eaſe, ſo that the ſheep diſcovers no marks of being new ſhorn, and looks like a lamb in that reſpect.

It would ſeem that there is a much greater proportion of the hair-bearing race among the breeds of ſheep in the ſouthern parts of the iſland; for I obſerve that Mr. Lisle, who lived in Hampſhire, and was an attentive obſerver, though he had heard of this young wool, under the name of *rowety*-wool, had never ſeen it. It is well known in Scotland, that this phenomenon does not depend on the leanneſs of wool-bearing ſheep, as he ſuppoſes, but takes place among thoſe that are in the beſt condition ſooneſt *.

The

* I find that moſt people have an idea, that the phenomenon of young wool riſing at the bottom of the fleece of ſheep before ſhearing, and all the peculiarities here mentioned, are entirely occaſioned by a check the ſheep have received from a want of food in the winter:

to

The pureſt of the hair-bearing ſheep I have ſeen, were ſome fleeces that were ſent to me from the Baltic, which were as evidently hair as the fleece of a goat, though finer and ſofter. The Ruſſians prefer this breed of ſheep, becauſe the fleece, when at its full length, adheres ſo much more firmly to the ſkin than wool does, that it laſts much longer when made into clothing than the other; for which reaſon, a wool-bearing ſheep among them is a great rarity.

Among the ſheep referrible to this claſs, there are ſome breeds which afford a ſmall quantity of a very fine ſoft wool underneath the hair, of which the *Argali* of PALLAS

to this opinion I cannot accede, for the reaſon after-mentioned; though I know well that when a ſheep has ſuſtained a great ſtreſs of weather during winter, it does happen that the old fleece ſometimes ſeparates prematurely from the ſkin; but in that caſe the fleece becomes matted, and aſſumes an appearance extremely different from the natural healthy riſing above alluded to. In this laſt caſe, the wool does not ſeparate in the early part of the ſpring as where it is matted; but it adheres to it till the month of June at leaſt, and even then it looſens in a gradual manner, as the young fleece begins to riſe, and always ſooneſt upon the ſheep in the beſt condition; which, on that account, are often ſhorn ten days or a fortnight ſooner than the others.

is a noted example; but the greateſt part of the varieties we know have none of this. I have never heard of an unadulterated breed of this kind that had ſtitchel-hair among the fleece, though it is often found among the mongrel breeds between this and the former. Neither have I ever heard of a finer kind of wool being found at the bottom of the fleece of any of the wool-bearing breeds.

The very long wool of Lincolnſhire, which I have examined with care, appears to be from a mongrel race, very nearly allied to this claſs, with a ſmall blend of wool in it; and is of a harder feel than ſome of the pure hairy breeds, ſome of which are tolerably fine and ſoft, and very tough and durable in work, and have a fine gloſſy ſilky-like appearance. I have had wool, of the genuine wool-bearing breed of ſheep, that meaſured 17½ inches in length, which was extremely fine and ſoft, and nothing reſembling that haſky kind of hair-wool in Lincolnſhire.

CLASS THIRD.

SHEEP *that carry* SHORT THICK HAIR, *which in no reſpect reſembles wool of any ſort.*

OF this variety of ſheep-ſpecies we have no breeds in Britain; but that ſuch ſheep do exiſt, we have the cleareſt proofs. So little are they known, indeed, in this country, and ſo little is it ſuſpected here that ſuch an animal exiſts, that I was not a little ſurpriſed when I firſt ſaw one of this kind, and therefore examined it with a good deal of attention. This creature was on board a Daniſh Eaſt-India ſhip that put into Leith-roads laſt ſeaſon [1794] and was bought, with ſeveral others of the ſame ſort, as they aſſured me, in the iſland of Madagaſcar. It was a ram of a good ſize, and was covered all over with a thick coat of ſhort thick ſtiff hairs, like thoſe of a horſe, but rather ſtronger in the pile, and ſhorter. The colour was a fine brown, The hair lay cloſe to the ſkin, and was very ſmooth and gloſſy, like the coat of a well-

 dreſſed

dreſſed horſe, in fine order. They aſſured me, it had never had any other covering on it but what I ſaw, and that all his companions were of the ſame ſort.

This fact threw the ſubject of ſheep into a new point of view, that I had never adverted to before; and enabled me to account for ſome phenomena reſpecting ſheep, that had puzzled me a good deal. In the account that Dr. PALLAS had given of the famous Boucharian lamb-ſkin furs, ſome of the peculiarities he mentioned appeared to me to be incompatible with the nature of wool, and much more nearly allied to that of hair. But, as I had no idea that any ſheep of this kind exiſted, I was perplexed about it, and could come to no decided opinion reſpecting it. Since then, I have had an opportunity of ſeeing a nightgown, lined with Boucharian lamb-ſkin fur, which, I find, conſiſts of nothing elſe but *hair*, without the ſmalleſt intermixture of wool. It is ſomewhat longer than the Madagaſcar ſheep's hair, ſofter, and gently waved by means of a little curl upon it, which gives to it the beautiful foliage-like appearance for which theſe furs have

have been ſo much valued; ſo that this forms a ſecond variety of this claſs of ſheep.

While I am juſt writing, I have received a letter from Sir JOSEPH BANKS, bart. on this ſubject; who ſays, "I once imported "three ſheep from Spain, which were as "ſleek and ſmooth as a horſe, and never, at "any ſeaſon, ſhowed the leaſt ſign of wool "or down in the moſt minute quantity." The fact, then, is inconteſtibly eſtabliſhed, that ſheep which produce as little wool as horſes, do exiſt; and, perhaps, they are much more common than we at preſent ſuſpect. The Boucharian breed of ſheep is kept in immenſe flocks, over the extenſive plains of Great Tartary. I have been alſo aſſured, of late, that they have a breed of this kind of ſheep in the iſland of Antigua.

And laſt winter [1796-7] I ſaw a ſheep of this ſort, in a field near Dulwich, in Kent, within three miles of the metropolis, feeding quietly, and very tame—ſo as to ſuffer me to come quite cloſe up to it, to examine the hair. Where it had come from, I could not learn; but, it ſeemed to

be a different variety from the Madagaſcar ſheep I had formerly ſeen. In colour, in particular, it was very different; the Madagaſcar ſheep being of a clear gloſſy brown, this one white, with a few dark-coloured ſpots upon it. So that this kind of woolleſs ſheep ſeems to be by no means rare. I am aſſured, that the greater part of the ſheep in India are of this ſort, though there are alſo many of the wool-bearing race to be found in thoſe regions.

A natural inference from theſe facts is, that ſince we find one claſs of animals, ſome breeds of which produce wool, and other breeds produce nothing but ſhort hair, in no reſpects reſembling wool, may not a ſimilar diverſity take place in regard to other claſſes of animals? And although it ſhould happen that the inhabitants of one country ſhould be poſſeſſed only of the hair-bearing breed of creatures of that ſort, like the Madagaſcareſe ſheep, and know nothing of any other ſort; yet, there is no reaſon, from that circumſtance, for them to conclude, that no other breed of that kind of creature exiſts. This train of reaſoning being ſuggeſted, it rouſed the mind to at-

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tend to facts; and I had soon occasion to observe, that so far from having reason to be surprised at finding breeds of sheep so much diversified, as above set forth, there were innumerable well-known facts, which, if adverted to, would have led to the same conclusion.

For example: there is no man in Britain, who has not had occasion to observe as great a diversity in regard to the coat of dogs as of sheep.

1*st*, The smooth-haired dog; examples of which, are, the Italian greyhound, and Spanish pointer.

2*dly*, The long-haired, soft, wavy-fleeced dog; as in the English spaniel, and Newfoundland dog.

3*dly*, The wool-bearing dog, or, at least, the dog that carries a coat, which for closeness, length, and softness, may be compared to wool, is very common. Some of them carrying an immense quantity of hair, of a long lank quality, and others carrying it of a close curled texture, very like the fleece of many kinds of sheep. The fleece of these creatures must be shorn at the beginning of summer, to let them be com-

 fortably

fortably cool; and I have ſeen it ſpun and worked into ſtockings, which could not be diſtinguiſhed from wool.

I have in my poſſeſſion at preſent, ſome of the hair of a dog of this kind, that I found in London, belonging to a black-ſmith, which is ſoft as wool, and which I find has among it a few hairs reſembling, *in every reſpect*, that kind of hair called *kemps*, which has been hitherto deemed quite peculiar to the ſheep kind.

N.B. There is a kind of fox, in Siberia, that carries a fur exactly like *wool*, as I have been aſſured by a gentleman who lived long there. The Ruſſian name of it, being literally tranſlated, is, *the little dog's fur*.

The ſame diverſity is obſervable in regard to goats: as,

1*ſt*, The ſmooth ſhort-haired goat, very common.

2*dly*, The long-haired ſhaggy goat, very common alſo. The hair of this kind of goat is uſually very coarſe; but underneath it, as in the long-haired breeds of ſheep, there is a quantity of wool, of an exceedingly fine quality, which may be ſeparated

from

from it about the month of June, by combing. From this circumſtance, it would ſeem that this wool, like the *wool* of the ſheep, riſes from the ſkin, and becomes looſened from it, while the hair ſtill adheres firmly to it. Of the fineneſs of the quality of this kind of wool, you may ſatisfy yourſelf, by examining the ſmall ſhred of a little web that will accompany this, of that kind of wool, which was manufactured under my eye here laſt ſummer. There was as much of it as made three full-ſized ſhawls and a waiſtcoat-piece, from whence the pattern ſent was cut. The chain is ſilk, as there was too little materials to make it of wool. Theſe ſhawls were compared with the fineſt India ſhawls that could be found in this place, and were deemed ſofter than any of them. The ſhawl-wool in India is preciſely of the ſame nature, and is obtained from the Thibet goat. I have examined ſome Thibet goats in this country, and find their hair rather longer and coarſer than the common European goat, from which it differs little. If it was a fair ſpecimen I ſaw, the *wool* was rather

leſs

lefs abundant on thefe than on the common goat.

3dly, The wool-bearing goat, for fo I think the Angora goat may be called, whofe hair is as fine, as foft, and as fit for work, as almoft any wool; but whether it *rifes* like wool, or is in this refpect like hair, I have had no opportunity of obferving. A fpecimen of Angora goats-hair, produced in Britain, will accompany this.

Whether there will ever be difcovered the fame diverfity of hogs, I cannot tell; but we already are acquainted, in Europe, with fomething analogous to the two firft-mentioned breeds of fheep, viz.

1ft, The fmooth fhort-haired Chinefe breed. The Jamaica breed of hogs belongs alfo to this clafs.

2dly, The long-haired breed, having wool under its long briftles; of this kind, is the fmall breed of hogs found in Orkney and the Shetland Ifles. Its briftles are very long and fhagged, and under them is found a very abundant quantity of wool, which is foft; but its peculiar qualities have not been as yet fufficiently inveftigated. I have

hitherto

hitherto heard of no breed of hogs that carries wool only.

Hence it appears, that the diverſity of animals that carry *wool*, is much greater than has hitherto been in general ſuſpected; nor can we at preſent ſay, with any degree of certainty, that there may not ſtill exiſt, in ſome corner of the globe, one or more of every ſpecies of domeſtic animals we are now in the cuſtom of rearing, and that do not carry wool with us, which may alſo carry wool, as well as ſome varieties of the ſheep. And ſince it is well known that the inhabitants of Europe have derived great advantages from ſelecting the *wool*-bearing breeds of *ſheep*, and rearing them in place of the ſmooth-haired ſort; it is equally certain, that, could we diſcover any varieties of the other domeſtic animals of the ſmooth-haired kinds, that we have been accuſtomed to rear, which ſhould afford *wool* as the ſheep does, the benefit we might derive from ſubſtituting theſe wool-bearing breeds, inſtead of thoſe hairy ſorts we now propagate, would be very great, if their qualities in other reſpects be nearly the ſame.

Of

Of all the varieties of domeftic animals we have been accuftomed to rear in Europe, next to the fheep, the bullock is the moft valuable. We, it is true, like the inhabitants of Madagafcar with regard to fheep, have been hitherto in the cuftom of rearing the fmooth-haired bullock only; and though, perhaps, like the inhabitants of Madagafcar, we may have accidentally heard that there are fome varieties of this clafs of animals that carry fomething like wool, in other parts of the world; yet as thefe have never come to our door, and prefented themfelves to us, we either doubt if fuch animals do exift, or conclude they would not thrive with us, and therefore fit ftill, contented with what we have, without making any efforts to better ourfelves. Is it not a well known fact, that we have continued for more than a hundred years paft to import wool from Spain in great quantities every year, without ever once attempting to rear the breed of fheep that produced it, though they were in a manner at our door? And is it not alfo known, that inftead of making a fair experiment to af-

certain

certain with precision whether that wool could be produced here or not, writers have been squabbling with each other about the possibility of a thing which could never be proved *pro* or *con* by reasoning, but by fair experiment only? And is it not also a fact, that although it be now proved to demonstration, by repeated experiments, that the wool of sheep brought from Spain, does not degenerate in Britain, there has been, till this hour, no attempt made to obtain a single individual of the *finest* breed of sheep from Spain? And is it not also a fact, that because those sheep that have been brought over from Spain, at random, have not been so fine in the carcase as some of the selected and improved breeds of sheep in Britain, that different persons are still disputing about the possibility of having sheep with a good carcase from Spain; as if a fact of this sort could be ascertained without accurate trial and experiment? Thus do we sit in our elbow-chairs, and argue, without data, till we reason ourselves into indolence and inattention, that make us remain contented with the dregs only of what might

might easily be within our reach. To men in these circumstances the words of the poet may be applied:

O leaden-hearted men, to be in love with death!

It is most certain, that the person who ventures to rouse the attention of men to the investigation of facts which they have not been accustomed to take notice of, must inevitably expose himself to the sneer of ignorance; but that is of little consequence, if it should chance to throw a single ray of light upon a subject that has been hitherto involved in darkness.

That there is nearly an equal diversity of breeds of cattle as of sheep, scarcely admits of a doubt; of which the following facts are proofs:

1st, The short smooth-haired breeds. Of these, the shortest I have seen, is a bull, of the *Zebu* kind, that was lately exhibited in Edinburgh, as a show. His hair did not exceed half an inch in length, and was very close, firm, and elastic. There are many breeds of cattle in Britain, the Holdernesse in particular, the hair of which is short and very smooth.

2dly,

2dly, The long ſoft wavy hairy breeds. Of theſe the Lancaſhire cattle are a good example; and many of the Highland breeds, ſome of which have manes like horſes.

3dly, The long ſoft wool-like bearing breed, of which the buffaloe, or rather biſon, of Louiſiania, is the chief. The hair of this animal is ſaid to reſemble clothing wool, in length, in thickneſs, and in cloſeneſs; a ſmall ſpecimen of this wool is incloſed, which I received from Sir Joſeph Banks, bart. But as the creature has never yet been domeſticated, or ſubjected to particular obſervation, by men whoſe judgment could be relied upon, our notions of it are but very imperfect. I do not hear that there are any long hairs upon this breed of cattle.

4thly, The long-haired wool-bearing breeds. Belonging to this claſs there are three varieties, obſcurely known, viz.

1ſt, The *Sarluc*, by ſome naturalliſts called the grunting ox, an animal of the Southern Tartary, which is not yet ſufficiently known. The fleece of this creature is

is ſaid to be thick and long, falling down below its knees, and of a very fine quality.

2dly, The Chittigong cow, of the higher Hindoſtan, which is deſcribed nearly in the ſame terms.—Its hair, or wool, is much eſteemed by the natives, and is applied by them to various purpoſes.

3dly, The Muſk ox, of Hudſon's-Bay. This animal is much better known to me than the former, as I had the deſcription from a gentleman in Edinburgh who lived many years in Hudſon's-Bay, and who had ſeen thouſands of them, dead and alive. The whole body of this creature, which is rather leſs than a middle-ſized ox with us, is covered over with a very cloſe fleece of long, ſoft, flexible hair, of a fine quality, which might be employed in manufactures for many of the ſame purpoſes as wool. Beneath that hair, and towards its roots, lies another coat of exceedingly fine wool, which could be applied in fabrics of the fineſt quality. It has been ſpun and worked into gloves and ſtockings, which are ſaid to be as ſoft as ſilk. The buffaloe-wool incloſed, I ſhowed to the gentleman, who

ſaid it was nothing like ſo fine as that of the muſk-ox.

The fleſh of this kind of ox is very fine, unleſs at the rutting ſeaſon, when it acquires a muſky flavour, from whence its name. Herds of many thouſands of them are to be found up the country, among the Eſquimaux, but none of them have ever yet been domeſticated. They do not ſeem to be either ſo wild or ſo ferocious as the wild breed of European cattle that are ſtill kept in Whittingham-park, Northumberland.

To ſhow what practical uſes may be derived from theſe facts, I ſhall beg leave to ſubjoin a few farther obſervations on ſubjects connected with this, that have reſulted, in ſome meaſure, from the enquiries which have been ſet on foot by the wool ſociety:

1*ſt*, It is now aſcertained, that all the varieties of ſheep yet known do readily intercopulate with each other, and that the progeny is a prolific animal, capable of continuing the ſpecies; but that in reſpect to its characteriſtic qualities, it is of a *mongrel* race, participating nearly alike of the

qualities of both its parents. And as theſe mongrel breeds may be intermixed with other varieties *in infinitum*, it may in many caſes happen, that new mongrels may be produced, in which the diſtinguiſhing peculiarities of the original breeds may be blended in all poſſible proportions, and loſt.

In like manner, the varieties of dogs may be blended and loſt, if no care be taken to preſerve them; and ſo of cattle: At leaſt, we know for certain, that the different European breeds may be ſo; and we have reaſon to believe, that the buffaloe, the zebu, and the other varieties that have not yet been tried in Europe, may be blended together.

2*dly*, The effects of climate and food, in altering the qualities of the *breed*, are found to be nothing; though the effect of theſe things upon the individual creature that is ſubjected to their influence, may, in ſome caſes, be very perceptible. For example:

It has been ſhown above, that the wool of *wool-bearing* ſheep is affected by heat or cold; but this is nearly in the ſame manner as heat or cold affect the mercury

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in the thermometer. It is a momentary impulſe, which ceaſes to operate the inſtant its influence is withdrawn; and the animal, which may have been made to undergo great variations of heat, returns to its former ſtate as ſoon as its original temperature is reſtored. But even this variation ſeems to be felt only by the *wool-bearing* breeds; and is, beſides, of much leſs powerful influence than has been uſually ſuppoſed. Nor is there is a ſingle fact, that has ever been diſcovered, that gives the ſmalleſt countenance to the generally-received opinion, that heat tends either to make the fleece thinner in pile, or to encourage the growth of hairs among it; far leſs, that it operates, as M. Buffon and his followers aſſert, in producing permanent changes on the deſcendants of the animals.

Heat likewiſe tends to accelerate the fattenning of ſome animals, to whom it is congenial; as the hog, to an aſtoniſhing degree.

Richneſs of paſture alſo tends to produce temporary changes. On the wool: there is reaſon to believe it tends to augment its

length *in ſome degree*, though but a little: it adds to its ſoftneſs and toughneſs; but, in regard to coarſeneſs or fineneſs, no fact has as yet been found to aſcertain that it has any ſenſible effect, though I am aware that *opinions* are here as deciſively adopted, as if the facts had been fully aſcertained. On the carcaſe: abundance of food is well known to augment the ſize of all animals to a certain degree, when compared with ſcanty feeding. A ſcarcity of food, approaching to the ſtate of ſtarvation, is alſo well known to render the wool which grows at that period of ſtarvation, brittle and unelaſtic.

3*dly*. The influence of breed, in propagating the qualities of the parent ſtock, or in altering the qualities of it at pleaſure, by blending it with others, may be ſaid to be all-powerful. There is not a ſingle fact, that I have ever been able to meet with, properly aſcertained, which tends to ſhow, that the diſtinguiſhing peculiarities of any breed of animals can be ſenſibly changed in its eſſential characteriſtics, by any change of climate, or any other circumſtance, except an intermixture of blood alone; but innume-

rable facts may be found that ascertain the contrary. The Persian and Arabian breeds of horses brought into Europe, are only changed by intercopulating with other breeds. The Chinese hogs may be continued for ages unchanged, if no cross be permitted. These facts are notorious; and every other fact upon this subject tends to establish the same conclusion.

4*thly*, Although the same breed of animals appears not to be liable to be changed by climate, or other extraneous causes, yet it is found by experience, that individuals may be met with, among every breed of animals, which are, in some lesser circumstances, different from others, though they still possess the general characteristics of the parent breed, arising from circumstances that have hitherto eluded our observation, and which it therefore exceeds our power either to accelerate or to retard. So strong also is the propensity of nature, in all cases, to produce its own kind, that if the individuals possessing these qualities, thus, as we would say, accidentally procured, whether beneficial or hurtful, be selected and put to breed with others that possess

qualities somewhat of the same sort, it is found, that the descendants of these selected animals will, in general, be possessed of the distinguishing peculiarity for which they were selected, in an eminent degree; though among these also some individuals will be found to have less of it than others: And if these least approved individuals be banished from the selected stock; and those, both males and females, which possess the wished-for quality in the most eminent degree, be put to breed together, the descendants of these will be still more improved: and by continuing this mode of selection for a great length of time, the improvement, as to this particular quality, may be carried to an indefinite height. In this way, may be produced an improved breed; which, though agreeing in the general characteristics with the parent stock from which it was selected, may possess some peculiar qualities in a much higher degree than it does.

It is of much importance to the practical farmer, to advert to this peculiarity in the economy of nature, because it puts it very much within his power to benefit himself,

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by attention and care, in regard to circumſtances that would otherwiſe ſeem to be entirely beyond his reach. For were he to be perſuaded that certain peculiarities he wiſhes to obtain, are neceſſarily dependant upon a temperature of climate he never can enjoy, or that certain bad qualities in the animals he breeds are inſeparably dependant upon the nature of his paſture, which it exceeds his power to change, he muſt of of neceſſity ſit down contented with what he has, without a hope of improvement; but if upon examining the facts above ſtated with attention, he ſhall find that the influence of breed is ſo powerful as is there ſtated, he will be at pains, in the firſt place, to look around him, to ſee if he can diſcover any breed poſſeſſing qualities, upon the whole, more valuable than his own, which is found to ſubſiſt on paſtures of a quality not better than his own; and when he has once found them, continue, with uninterrupted attention, to ſelect the beſt in all reſpects, particularly thoſe that thrive beſt among them, to breed from. This has been done by Mr. BAKEWELL, and thoſe who have adopted his ſyſtem, with ſuch ſucceſs,

as not only to eſtabliſh the principle for which I contend beyond a doubt, but alſo to give room for encouraging others to adopt a ſimilar plan for improvements in other reſpects, than thoſe that ſeem, hitherto, to have come within the compaſs of his plan.

5thly, There ſeems to be no reaſon for believing that any one peculiarity we may be in queſt of, is neceſſarily connected with, or dependant upon, any other peculiarity in the animal creation. For example: The improvers of live ſtock, in the preſent age, hold it out to view, as a general principle, that a facility in fattening is invariably connected with certain peculiarities in ſhape; and of courſe they conclude, that, wherever theſe peculiarities of ſhape are to be found, the facility of fattening will be found alſo, and the reverſe. This, I contend, is a falſe principle, and I venture to ſay, that when the facts ſhall come to be thoroughly inveſtigated, their concluſion will be found to be erroneous; indeed it is in ſome degree departed from in *practice* already, though in theory the principle is ſtill adopted, without limitation. A few years ago, ſhortneſs of leg was deemed a point indiſpenſably

difpenfably neceffary in a feeding beaft, and it went the length of almoft being deemed —the fhorter the better: this is now no longer contended for. Many of the charac-teriftics of the prefent day will, in like manner, gradually fall into difufe, as people come to open their eyes on this fubject. The fact is, I have feen animals that had a powerful tendency to fatten, which are almoft, in every refpect, the reverfe of the fhape moft highly efteemed at prefent, and the contrary. And by referring every perfon who has had opportunities of obferving *many breeds* of the fame kind of animals, to his own experience, I have no doubt, but he will eafily recollect inftances of the fame kind; or, at leaft, if his mind be unprejudiced, that he will foon have occafion to obferve it. To that experience, then, whether paft or to come, I refer on this occafion.

One circumftance, however, it is neceffary here to advert to, viz. that as the breeds of animals from which the felection was begun, were originally of very good kinds, and chanced at the fame time to poffefs thofe fhapes that are now deemed fo effen-

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tially requiſite; and as the improved breeds that have been ſelected from theſe are found to poſſeſs thoſe ſhapes, it is by no means an unnatural concluſion to infer, that theſe ſhapes are in ſome degree inſeparably connected with the propenſity to fatten eaſily. Had it chanced that equal pains had been beſtowed upon ſelecting from another good breed that was differently ſhaped, the prejudice would have been equally ſtrong, in favour of that ſhape. But as the breeds that have been hitherto the object of ſelection, have got the ſtart of all others in point of improvement, it is probable the prejudice in favour of their ſhape may long continue to prevail; nor do I wiſh it to be underſtood that I have any prejudice againſt the ſhapes recommended. Far from it, for I think them very beautiful—I only wiſh to ſay, that that circumſtance is not *eſſentially* connected with the other; for as every error, when admitted as a truth, leads to unforeſeen and often pernicious conſequences, though the opinion objected to may not be of much conſequence in the particular inſtance now under conſideration, its influence

may be very unfavourable in regard to others. Allow me to add one farther illuftration on this head, before I put an end to this long paper:

If it be admitted, that a faculty of fattening eafily be neceffarily connected with certain peculiarities of fhape, merely becaufe it chances accidentally, as I will fay, that thefe two peculiarities happen to be united in that breed of animals which has been brought forward to notice; we ought, by the fame mode of reafoning, to infer, that that quality of fattening eafily, is as neceffarily connected with coarfenefs of wool, or lightnefs of fleece, or any other ufelefs or hurtful peculiarity, if it fhould fo happen that the favourite breed chanced to have coarfe wool, or a thin fleece, &c. The confequence of this conclufion would be, that every man who wifhed to improve the carcafe of his fheep, would turn away from every breed of fheep that carried fine wool or a clofe fleece, as he now does from thofe breeds that have long legs, or what is deemed in other refpects, improper fhapes; and fine-woolled fheep, carrying clofe fleeces, would come to be entirely neglected. But

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if, inftead of this prevention, he fhould be convinced, that it might be very poffible to find a fheep that would have a tendency to fatten kindly among thofe breeds that carry very fine wool and clofe fleeces; he would be as anxious to felect from thefe breeds, as from others; and probably as fuccefsful too, if he had fet out at the fame time, with the man who began to felect from the coarfe breed. I am, myfelf, perfectly fatisfied, from a variety of facts that have fallen under my own obfervation, which would fill a volume nearly to enumerate, that fine wool, for example, is neither neceffarily connected with thinnefs of pile, (the Spanifh fheep carry the clofeft pile of fleece yet known in this country) with fhortnefs of ftaple (I once had a fleece of wool, that meafured 17 inches and half, which was finer than the beft Spanifh-wool I could buy in London, and extremely foft) with tendernefs of conftitution, with a tendency to fatten flowly, or with any one quality that can be named, though it may be *accidentally* connected with thefe: And I have not a doubt, but when the eyes of mankind in general fhall be opened, fo as

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to admit of their examining the facts that fall under their notice, without prejudice, they will be able, in time, to ſelect breeds that ſhall be diſtinguiſhed not only for *one* valuable peculiarity, to the excluſion of all others, but even to obtain that valuable peculiarity conjoined with moſt, if not all the other peculiarities that can be deſired. That period is, I fear, ſtill at a great diſtance.

But, if theſe remarks ſhall tend in any degree to call the public attention to this ſubject, whether with a deſire to refute or to confirm theſe remarks, it will equally anſwer the end in view, which is to remove hurtful prejudices, and to diſcover the truth. He who does ſo, is on my ſide, alike if he refutes by juſt reaſoning, from well-eſtabliſhed facts, as if he confirms theſe remarks.

The SECRETARY *of the Bath and West of England Society, to Dr.* ANDERSON.

THE Secretary of the Bath and West of England Society, begs leave, in the most respectful manner, to convey to Dr. ANDERSON, some few remarks and queries, which arose in the Committee, respecting his excellent paper on Wool-bearing Animals. In general, as might be fairly expected, this paper was much approved; but doubts arising on two or three sentences, they will be set done in order, and the Doctor will greatly oblige, by giving them a reconsideration and reply, as early as shall be convenient to him.

1*st*, "And is it not also a fact, that "though it be now *proved to demonstra-* "*tion*, by repeated experiments, that the "wool of sheep brought from Spain *does* "*not degenerate in Britain**, there has "been till this hour, *no attempt made to* "*obtain a single individual of the finest breed* "*of sheep* § *from Spain?*

* Query

* Query from the Committee. *On what experiment or experiments is this fact, if it be one, founded?*

§ From the same. *Has not the attempt been made by the king, and succeeded? Or, at any rate, are not the rams selected and sent to him by the Marchioness Del Campo, to be considered as the best?*

2dly, "Nor is there a single fact, that "ever has been discovered, which gives "the smallest countenance to the gene-"rally received opinion, that heat tends "either to make the fleece thinner in "pile, or to encourage the growth of "hairs among it. Far less that it ope-"rates, as M. BUFFON and his followers "assert, in producing permanent changes "on the descendants of animals †."

† Query from the Committee. *Is this a clear case? Do not our sheep sent to and kept at the West-Indies, rather prove the contrary?*

To JAMES ANDERSON, Esq. LL.D. F.R.S.

ANSWER *to the* SECRETARY.

DEAR SIR, *Saturday, Feb. 25th*, 1795.

I THANK you for your very kind letter of the 13th inſtant, which only came to hand on Thurſday laſt; I embrace the firſt poſt for acknowledging that favour, and of giving anſwers to the queries your Committee have done me the honour to propoſe.

1ſt, A variety of experiments have been made with the Spaniſh breed of ſheep, for three years paſt, by many of the members of the Society of Britiſh Wool. I have ſeen many ſpecimens of the wool of both parents, and of the progeny, which have been compared together, by the members of the Committee and others; and in no inſtance, has it ever been obſerved, that the wool of the progeny, where the breed was pure, was *coarſer* than the average of the parents. Of the effects of croſſing, and other

other peculiarities, affecting the wool in particular cafes, I have not time to fpeak; I fhall only obferve, that, in general, the Spanifh fheep that have come to Scotland have not been found to thrive, being liable to many difeafes, efpecially the foot-rot. You are aware that bad health affects the *quality* of the wool, in a very remarkable degree, in fome cafes.

2dly, The king has certainly got fheep from Spain, as has the Society for Britifh wool. But do the gentlemen of the Committee believe, that Mr. BAKEWELL, or any other eminent breeder, would have thought he could have obtained the very beft kinds of Britifh beafts, by getting the Duchefs of * * * * *, or any other Duchefs or Duke in the kingdom, to order her or his fteward to buy the beft, and fend them to him? Such are not the fteps required to make improvements of this kind. Do we not all know, that every perfon of high rank is liable to be impofed upon by their fervants and dependants, in almoft every thing? And what would have been the confequence, if the fteward had

had wiſhed to fruſtrate the liberal intentions of his miſtreſs? No precautions have been adopted to guard againſt this. We know, that the *fineſt woolled* Spaniſh ſheep have not been ſent, becauſe finer Spaniſh wool can be bought than any of them carried. And I have very great reaſon to believe, from the information of perſons who have ſeen the flocks in Spain, that there are fine woolled ſheep in Spain, much ſuperior *in carcaſe* to any we have got *.

3dly, If any of the gentlemen of the Committee knows of any well-authenticated fact, which proves that the fleece degenerates, as ſpecified, in the Weſt-Indies, I ſhall be glad to be informed of it. I know of none, though I know it has been aſſerted ten thouſand times, by perſons who never had adverted to the fact; before I did advert to it, I myſelf believed it firmly; ſince I inveſtigated the caſe with attention, I have

* For the precautions neceſſary to be obſerved in ſelecting ſheep of the beſt ſort, ſee Account of Ruſſian ſheep, Appendix fifth.

been

been obliged to abandon that opinion *. When the gentlemen of the Committee advert

* It is very easy to account for the origin of this popular opinion. Wool is not an object of attention to any person in the West Indies; it cannot be there manufactured, and there are no uses to which they can apply it in its unmanufactured state, of course, the fleece of the sheep is entirely neglected, and in that state the wool of European sheep when carried thither will not be shorn, but will be suffered to loosen from the skin, and drop off of itself, the consequence of which will be, that if there were any kemps among the wool, which is very often the case, these hairs will remain fixed in the skin while the wool falls off; in which state the animal is perfectly bare of *wool*, and in its stead, the body is seen to be covered with a thin coat of long coarse straggling hairs only.—This fact being several times observed, is more than sufficient to give rise to an opinion, that all sheep which come from this country, have the wool transformed into hair, and this will naturally be ascribed to the influence of the climate, though nothing can be more certain than that the same phenomenon would take place in Britain. In fact, it does take place every year in Shetland, where the practice of sheering their sheep does not prevail. So much for the individual sheep, that have been sent out from this country.

With regard to the descendants of these sheep, as the few sheep that go from this country are suffered to run at large among the native sheep, they of course will intercopulate with them, so that the progeny will be a mongrel

vert to the numberlefs opinions that are readily admitted, without proof, as facts refpecting wool and fheep in Britain, they will not be furprifed at this opinion refpecting fheep in the Weft-Indies, being admitted. I have been in the cuftom, for many years paft, of admitting no affertion, on fubjects of this fort, without proofs; and in fearching for proofs on this head, I have found a great number of facts, that have obliged me to abandon my former opinion. No opinion is more univerfal in the Weft-Indies, than that the fheep which are deemed the native breed of the ifland of Jamaica, carry *no* wool at all, but hair only. I had an opportunity, I think, of fending to you a fpecimen of the natural fleece of one of thofe fheep, which confifts, for the greateft part, of wool, perhaps *finer* (un-

grel race, approaching to the nature of the native fheep. —Thefe being once more croffed, will approach nearer to their nature, and fo on, till, in a fhort time, they will be in no refpect diftinguifhable from the native fheep.—Here, then, is a pure metamorphofis of the kind—but it is a change which has no dependance on climate.—The fame thing muft have happened, under fimilar circumftances, in Siberia or Lapland, juft as much as in Jamaica.

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doubtedly ſofter) than the beſt Spaniſh wool.

Pleaſe to accept of theſe haſty notices in good part, and believe me to be, with great ſincerity,

Dear Sir,

Your obliged humble ſervant,

JAMES ANDERSON.

Mr. Wm. Matthews.

ADDITIONS

Made to the above, in the year 1797.

SINCE the paper above was written, two valuable animals of the wool-bearing claſs have come to my knowledge, with which I was then entirely unacquainted—one of theſe is the Jamaica breed of ſheep, concerning which, I have mentioned the nature of its hair at page 240, in putting this edition to the preſs. The ſheep itſelf was diſcovered in Britain, by Sir Joſeph Banks, Bart. who favoured me with the following account, in a letter, dated Nov. 1794. Sir Joſeph had occaſion to viſit an acquaintance, immediately on that gentleman's return from Jamaica, and in walking upon the lawn, before dinner, he ſaw a ſheep of a very unuſual appearance.—He aſked what ſort of a ſheep it was, and was told it was one of the native Jamaica ſheep, which had been put on board for live ſtock, but having had a quick paſſage, its life had been ſaved. Sir Joſeph, who had honoured me with ſome communications reſpecting wool juſt

juſt before that, expreſſed a deſire to ſee its wool. Wool! ſaid the gentleman, it carries no wool, but only hair.—Well, ſaid Sir Joſeph, let me ſee the nature of its fleece, whatever it be.—On that the gentleman called the ſheep, which, being quite tame, came up to him.—He then plucked a lock between his finger and thumb from the back of the ſheep, and looking at it for ſome time, he exclaimed, with ſome degree of aſtoniſhment—here is actually ſome wool, and until this moment I never did believe that theſe ſheep carried the ſmalleſt portion of wool whatever, though I have ſeen great numbers of them daily for many years paſt! Sir Joſeph examined it alſo, and ſent the lock, exactly as it was pulled, knowing I ſhould deem it a great curioſity. The lock conſiſted of hair of the kind above deſcribed, and of more than an equal quantity of wool of a ſingularly fine quality; being much finer than any Spaniſh wool I ever ſaw, and as ſoft as ſilk.—At that time it was about an inch long, and by the uſual ſhearing time, I ſuppoſe it might have attained nearly to two inches in length;

and as the hair could be eaſily ſeparated from the wool, ſeeing it is uniformly about half an inch longer, I have no doubt but the fleece of this animal would be of as great value as the beſt fleeces that have been ever reared in this iſland; as the wool appeared to me to be equally ſoft with Vigonia wool, which frequently ſells here, when clean picked, at the rate of one guinea per pound,—and it has the advantage over that, in being of a pure white; ſo that it admits of being dyed of any colour. I conſider this breed of ſheep, therefore, as a very proper object for experiment.

It has been, in general, believed, that the breed of ſheep juſt now deſcribed, which are found in Jamaica, are the very ſame ſort with thoſe in England, which have degenerated from their original ſtate, in conſequence of the influence of the climate, which is ſaid to convert the Engliſh wool into hair,—and it has been often ſeriouſly affirmed to me, by reſpectable perſons, that there could be no doubt of the fact, that Engliſh ſheep are invariably transformed into that kind of animal after being a few months in Jamaica. I had been, however,

ever, aſſured by Dr. Wright, who was an attentive naturaliſt, and had lived many years in Jamaica, that they were a diſtinct breed.—But had I never heard any ſurmiſe of that ſort, nor been able to account for the prevalence of that opinion in any way, the fact above ſtated puts the matter beyond a doubt.—No ſheep that are reared in this iſland, ever carried a hair of the kind which is natural to that ſheep; nor have we any wool that can admit of being compared with it, in point of fineneſs. We have never, in ſhort, ſeen any wool of the ſame ſort in this iſland; and that breed of ſheep ſeems to be more nearly allied to the Argali of Pallas, than to any other breed of ſheep hitherto deſcribed. None of the breeds of ſheep reared in this iſland, approach to it in the ſmalleſt degree. It is curious to obſerve that the *hair* of this animal is much coarſer, and its *wool* much finer, than can be found on any of the ſheep reared in Britain; ſo that, by the vulgar hypotheſis, it would ſeem that the climate produced two effects on the ſame animal at the ſame time, directly the reverſe of each other!

The

The other valuable wool-bearing animal of which I have received notice, is what has been conjectured by Dr. Anderson, of Madras, with much seeming probability, to have been the animal which gave rise to the famous Argonautic expedition, as the wool of it may, in the strictest propriety, be denominated the GOLDEN FLEECE. Hitherto it has been, in general, supposed that the epithet *golden* was applied to the fleece of Colchis, merely allegorically, in allusion to its value; but, from the specimen sent to me, it may be literally and truly called such; for I never saw any natural animal production, which so nearly assumed the appearance of gold as that does. A bit of the skin, about the size of the palm of the hand, with the wool adhering to it, was brought to Dr. Anderson, by a Sepoy, who had been employed in a military expedition to the northern parts of India, and all the account he could give of it was, that it was part of the pillage that had been obtained after the overthrow of one of the chiefs in those regions. A part of this Dr. Anderson sent to me, and it is now in

my

my poſſeſſion. The pile is ſoft and fine; its colour is a bright yellow, of the colour of gold, and it has a gloſs luſtrous as ſilk. In length, it is about nine inches; nor is it frizzed up, like moſt kinds of wool, but hangs down with a gentle wave, tending to a kind of ſpiral curl upon it, very much reſembling the wool of the Angora goat in every reſpect, except the colour. It is evidently not dyed,—for not only is the bit of ſkin to which the wool adheres of its native colour, but there is plainly perceptible, a ſmall variation in the tint, between the roots and the points of the wool, the roots being rather the lighter of the two, which would not have been the caſe, if it had been dyed. In ſhort, the beauty of this lock is ſuch as to have attracted, in a very high degree, the admiration of all who have ſeen it;—and even in the preſent ſtate of arts, a manufacturer gave it as his opinion, that it was an article of ſo great value, that he would purchaſe it, if it could be procured, at an exceedingly high price:—but if we look backward to thoſe diſtant periods when ſilk was not at all known in Europe, and when

when the art of dying was but in its infancy, we can eaſily conceive, that the value of an article of this kind would be deemed ineſtimable.

We have to regret that ſo little is known of the animal which produces this fine fleece.—All that is as yet done, is, to aſcertain that ſuch an animal does actually exiſt; and that, of courſe, it is not beyond the bounds of *poſſibility* to diſcover it. In that enquiry, Dr. Anderſon, at Madras, is engaged at preſent, and no man, from the great range of his correſpondence, the univerſality of his acquaintance, and the reſpectability of his character in India, is ſo likely to ſucceed in the diſcovery of it as himſelf: Nor is any one ſo likely to procure the living animal, if it ſhould be diſcovered. But ſuch animals, if obtained, ought not to be delivered up as toys to princes, or their dependants, to play with.

Since the fact is now undeniably eſtabliſhed, that there are various *breeds* of the ſame ſpecies of animals, which differ radically from each other, and preſerve theſe diſtinct characteriſtics under every change of climate or management, while the

blood

blood continues uncontaminated; and ſince we find that theſe variations reſpecting the fleece, or external coat of hair, are ſo very great as has been above made evident, we have reaſon to believe, that the variations which may take place between different breeds of the ſame ſpecies of animal, reſpecting their other qualities may be equally great and ſtriking as thoſe which regard the fleece; it therefore behoves us to advert to all the peculiarities of every different breed or variety of animals, with much more care than we ever yet have been accuſtomed to do, if we wiſh to carry our improvements to the higheſt degree of poſſible perfection. This opens up a tract for enquiry, that is as yet entirely unexplored; for, ſo long as an idea prevailed that the different varieties of the ſame ſpecies of animals were merely caſual deviations from the ſame parent ſtock, theſe accidental variations muſt have been conſidered as of a nature ſo fleeting and periſhable, as not to be worth the pain of accurate inveſtigation.

In conſequence of this mode of reaſoning, the real qualities of the different kinds

kinds of wool and hair, produced by different breeds of ſheep, have ſcarcely been at all adverted to, becauſe, where a variation was perceived, it was attributed to climate, food, &c.—and not to the nature of the breed.—Hence it was inferred, that under the ſame temperature, and with the ſame food long enough continued, all the varieties would be nearly the ſame. By a ſimilar mode of reaſoning, we have acquired the habit of thinking the other qualities of all the varieties of any one claſs of animals are actually the ſame; and that if they appear at times to differ, this is owing to the operation of accidental circumſtances only: of courſe, we have been equally careleſs in obſerving the other qualities as that of the wool, ſo that many of theſe peculiarities have totally eſcaped our notice.—I ſhall beg leave here to give ſome hints reſpecting theſe, merely to forward this ſpecies of inveſtigation:

The *ſize* of animals, like the qualities of the wool, have been ſuppoſed accidental —That this is not the caſe, admits of clear proof. None of the creatures we rear, are ſo much under our management, or ſo

univerſally

universſally ſubjected to our obſervation, as the dog; nor are there a greater diverſity of breeds to be found in any ſpecies of creature.—In reſpect of ſize, in particular, this is very remarkable, for the ſmalleſt lap dog, when compared with the largeſt ſized maſtiff, is not, perhaps, one twentieth part of its bulk. And that this is not owing to the fullneſs of feeding, is very evident, ſeeing that theſe ſmall dogs are in general much better fed, and more highly pampered than thoſe of the largeſt ſize. Hence we are led to conclude, that there are varieties of the ſame ſpecies which are radically different in point of *ſize*, and which cannot be made to approach to each other, by any mode of management whatever, where the blood is unmixed.

The ſame thing is obſervable in other animals. The breed of cattle peculiar to the highlands of Scotland, may be made as fat as the Holderneſs breed; the Shetland breed of horſes as the large black dray-horſes in England, and the Chineſe hog as the Berkſhire pig; but no management can bring theſe ſmall breeds to equal the

the others, in point of ſize, when equally well fed. Obſerve, I do not ſay, that full feeding will not raiſe the ſize; for it is an undoubted fact, that every animal when well fed, will riſe to a larger ſize than where it is not well fed; but this rule applies equally to all animals, to the larger as well as the ſmaller, ſo that if equally well or ill fed, they will ſtill preſerve their diſtinctive ſize.

Different breeds of the ſame ſpecies vary from each other alſo in reſpect to ſhape. The pug-dog, the ſpaniel, the greyhound, the maſtiff, are all diſtinguiſhable from each other in point of ſhape, by the ſlighteſt glance of the eye; nor can any management tend to confound them, if the breeds are preſerved unadulterated. So is the Devonſhire, the Lancaſhire, the Holderneſs, the Kiloe cattle; the Shetland, the Lanarkſhire, the Suffolk, the Leiceſterſhire ſheep; the Swediſh, the Holſtein, the Spaniſh, the Arabian horſes; each of which can be recogniſed by a glance of the eye, when compared with the others; and they are all equally permanent.

Different

Different breeds vary from each other alſo, to an aſtoniſhing degree, in reſpect to their propenſity to increaſe in corpulency by abundant feeding. No art can ever bring the grey-hound to be as full of fleſh as a breed of lap-dogs (I believe they are called ſhock-dogs) which have a propenſity to fatten more than any others ;—and, it is not a little remarkable, that ſome of the leaneſt kind of dogs, eat the moſt food of any, in proportion to their ſize. It has been often remarked, that a grey-hound is the moſt voracious of all dogs, and that a maſtiff, in proportion to its ſize, eats very little, though it may very eaſily be fattened. The blood-horſe and the alderney-cow, can never be made ſo fat as many other varieties of their ſpecies.

Theſe obſervations lead to very important concluſions, to the farmer ; for if ſuch remarkable diverſities be occaſioned merely by the *breed*, it behoves him to be exceedingly attentive to this article, and to inveſtigate, with the moſt careful impartiality, the peculiarities which eſſentially diſcriminate one breed from another ; to

consider each peculiarity of every breed, individually and separately, and not to blend them in the gross, as has hitherto been done. It would lead me much farther than I at present choose to go, were I to enter minutely into this subject—my object is not at present to teach others, but merely to put them into a train of instructing themselves; and, with that view, I shall merely glance at a few other circumstances, before I put an end to this Essay.

It is not the abundance of food, that will produce a large breed of animals in any place, though the want of food will every where stint them in size. Hence we are not to conclude, that wherever a small breed of any domestic animal prevails, it must be a poor barren country.—If the animals be fat, it is a proof they have abundance of food, whatever be their size—though if they be thin, it is not a proof that they are in want of food. The Shetland poney is of a size as small as that of the island of Tiree; but the first is a plump strong-made animal, that is almost continually fat, the last is a thin puny

puny creature, that looks always ſtarved, though its native food is richer. In like manner, the Alderney-cow is a hard-boned, hungry, ſtarved-like creature, when even on the beſt of graſs. The Kiloe is not much higher in ſtature, but it is a burly looking creature, compared with the other, and has a tendency to fatten kindly wherever it has food enough. The firſt is a native of a fine climate and good ſoil; the laſt is found in an ungenial region, and very unfertile country.

From theſe conſiderations, it will appear, that ſeveral of the queſtions which have been keenly agitated among warm diſputants, for many years paſt, do not admit of a ſolution in the way they have contended for. One party, for example, maintains that it is more advantageous to rear large than ſmall beaſts; and, in confirmation, he produces a fact, by which it appears, that in that particular caſe, the large beaſts were, in truth, the moſt profitable of the two. Another, on the contrary, maintains, that ſmall beaſts are univerſally more profitable than large, and ſtates a fact, which proves clearly, that

the ſmall breed was indeed more beneficial than the large. They may be both right as to the particular facts alleged, and both wrong as to the general concluſion. It is not the ſize, but the other peculiarities of the individual breeds that influence this queſtion; ſeeing two breeds, of equal ſize, may poſſeſs properties extremely diſſimilar. It is, therefore, a groundleſs prejudice, either to approve or to condemn a particular breed, from adverting to its ſize only; of courſe, we ought to reject none from the particular inveſtigation of its qualities, above recommended. For this reaſon, the Muſk ox, of Hudſon's Bay, which is rather ſmall; the Biſon of Louiſiania, which is of a larger ſize, and ſtrong, both of which fatten kindly; the Alderney-cow, which is alſo ſmall, but valuable on account of its milk; and the Arnee, of Hindoſtan, which is by far the largeſt of the cattle-tribe yet known, ſhould each of them have their reſpective peculiarities diſtinctly aſcertained.

Of all the animals of the *Bos* tribe, the Arnee is, doubtleſs, the largeſt yet known;

known; and although largeneſs of ſize be not in itſelf a quality that ought to recommend an animal to favour; eſpecially where it is to be ſuffered to graze upon the meadows, where the exorbitant weight of the creature may be ſometimes hurtful; yet, there may ariſe occaſions, in which great bodily ſtrength may be of ſingular utility: and as it is poſſible to feed beaſts always in the houſe, ſhould the animal be in other reſpects deſirable, the damage that might be done by its weight in paſturing, may be thus entirely avoided. This creature, when tamed, is gentle, and very ſuſceptible of being trained to any purpoſe that may be wanted; but, with its other qualities, we are very little acquainted. It is known in the higher parts of India, where it is uſed as a beaſt of parade, nearly in the ſame manner as the Elephant, to which, in point of ſize, it more nearly approaches, than, perhaps, any other animal, that is yet known to us, as I chanced accidentally, to gather from the following incident:

Mr. William Haig, while firſt lieutenant on board the Hawkeſbery East Indiaman,

diaman, then in the river of Ganges, about fifty miles below Calcutta, obſerved an animal in the river, alive, but floating towards the ſea, carried down by the current; a boat was immediately put off, and the creature ſecured by means of a rope thrown over its horns, and towed towards the ſhip. They were ſurprized at the largeneſs of the ſize of the animal; and being juſt come into the river, from Europe, it was accounted a glorious prize, and inſtantly ſlaughtered, for the ſake of freſh proviſions. It was found to be a bullock of only two years old, yet when cut up, the four quarters weighed full 1450 pounds. From this datum we cannot ſuppoſe, that a beaſt of this kind, of full ſtature, and completely fatted, would weigh leſs than 4500 pounds; for we know that a lean bullock, of two years old, will not amount to one-third part of the weight that the ſame animal would have attained at nine years of age, when fully fatted; and as this creature muſt, in all probability, have been carried down the river for, perhaps, a thouſand miles, before it was catched (none of theſe cattle, that

I have

I have heard of, being bred lower than Plaſſy) we muſt ſuppoſe that it would be very much emaciated; yet all on board the ſhip thought it excellent eating. As the head, feet, ſkin, entrails, and tallow, of a fatted animal, weigh very little leſs than the four quarters, we ſhall ſee reaſon to believe that ſome of theſe, when alive, may be found, which will not be leſs than from 80 to 90 cwt. upwards of four ton weight! ſo that it muſt be a very ſtately creature. They are ſaid to be ſometimes eleven or twelve feet in height.

The horns of this breed of cattle grow right upwards, nearly in the ſame plane with the face. At firſt they ſpread outward, but as the creature grows older, they gradually bend inward, till at laſt they form nearly a circle, of a large ſize. I ſaw an Indian painting, in the poſſeſſion of Gilbert Innes, eſq. of Stow, in Edinburgh, repreſenting a fight between an elephant and two tigers; a kind of entertainment, ſometimes given by the grandees of India, for the amuſement of the public. In this painting many people were preſent; ſome elephants were there alſo, under the care of attendants, and

three of theſe cattle were there ſeen alſo ſtanding quietly, under the charge of their keepers, who were mounted upon them, nearly as the cornac is upon an elephant; nor were they repreſented as much, if at all, inferior in ſize to that monſtrous animal.—The colour was uniformly black, except a tuft of red, or rather flame-coloured hair, pretty long, on the top of the forehead, exactly between the horns. It was guided by a rein faſtened to the griſtle between the noſtrils. It is therefore plainly a domeſticated animal, and its appearance is of the moſt gentle and inoffenſive kind.

The Biſon, or, as it is commonly called, the Buffaloe of Louiſiania, is alſo a beaſt of a large ſize, and great bodily ſtrength, and has a propenſity to fatten kindly. It was not known that it could be very eaſily domeſticated till of late; but I find, among other peculiarities reſpecting this creature, mentioned in the Seventh Volume of the Bath Society papers, written by a Mr. Turnbull, a very ſingular and eaſy method of catching them, which appears to be well known to the inhabitants of the back ſet-

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tlements in America, who often go out to hunt the Buffaloe. He ſtates, that if a female who has a ſucking calf at her foot, chances to be killed, the calf never leaves its dam, even when the hunter comes up, but ſtands quietly by, and follows the body of its mother wherever it is carried, were it even into the heart of a city; and as the calf is eaſily tamed when once got into hand, it ſeems to be often reared, in the back ſettlements, as a domeſtic animal. The writer of that paper does not there ſpecify any of its other qualities, but its ſtrength alone, which, he ſays, is much greater than that of the European ox, and its ſtep longer, on which account he ſtrongly recommends it as a beaſt of draught.

The *Zebu* breed of cattle has been alſo imported into this country, I find, from India, by ſeveral gentlemen, and is found to thrive here, and to breed perfectly well, ſo that it is probable, its qualities will come in time to be accurately aſcertained. In regard to one particular, both theſe breeds poſſeſs a peculiarity, that is well known to be totally diſtinct from any of the breeds of cattle that are natives of this country. The peculiarity

peculiarity which diſtinguiſhes the Biſon from other varieties of the *Bos* tribe, is a large hump upon the ſhoulder, which when cut up, is found to afford a fleſh that is of a quality totally diſtinct from that of any other part of the body, and is univerſally eſteemed much more delicate eating. The *Zebu* is alſo diſtinguiſhed from other creatures of the ſame genus, by a particular kind of excreſcence, that riſes from the ſhoulder alſo, but in a manner totally different from that of the Biſon; and the quality of the fleſh of this excreſcence (which is of a conſiderable ſize) is different from any meat furniſhed by our cattle, and differs alſo from that of the Biſon. This is deemed ſuch a peculiar delicacy, that I have often heard gentlemen who have been uſed to it in India, ſay, they found all the meat in this country, harſh to their palate, ſo that they could with difficulty bring themſelves to eat of it. It is not impoſſible but the meat in the other parts of the body may alſo differ conſiderably from our's, and from each other. The ſkin alſo of theſe animals may be found, upon trial, to be poſſeſſed of properties that may render it highly va-

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luable in manufactures; particularly that of the *Arnee*, which is probably, in many respects, different from that of the smaller animals of the same genus. It is certain, that the Indians make of the skin of the Bison, manufactured in their manner, a kind of leather, that is soft, tough, and very light, of which they form a kind of jerkin, or a shield, perfectly capable of resisting the force of an arrow. Whether this quality depends upon the nature of the skin, or on the mode of manufacturing it, remains to be ascertained.

I shall just add one other hint respecting *varieties* of animals of the same species, with a view to lead to an investigation, that never has yet, that I know of, been the subject of elucidation. We have seen above, that different *varieties* of the same species possess certain permanent and distinct peculiarities, that cannot be altered but by an intermixture of blood. Those peculiarities that I have taken notice of above, respect chiefly external circumstances, which are very obvious to the senses.— There are other peculiarities, however, of a more obscure nature, if I may be allowed

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to adopt that expreſſion, which, though equally uſeful, are not ſo eaſily aſcertained by ſenſible marks which admit of accurate comparative trial, but which are ſtill eaſily recogniſed, when you take two breeds that differ very much from each other.—Of this nature, is what is called hardineſs, or perſevering firmneſs under fatigue, often called *ſpirit*—as contraſted to that ſluggiſh want of mental and muſcular exertion, which is called *ſoftneſs* in horſes; the blood-horſe, for example, and ſome other noted breeds of active horſes, compared with the large black dray-horſe. Of a nature equally obſcure, though, I am ſatisfied too, equally diſtinct from each other, is the taſte and flavour of the fleſh of different breeds of the ſame kind of animal, though this circumſtance does not ſeem as yet ever to have attracted the public attention in the ſmalleſt degree. Every perſon knows, however, that there is an exceedingly great difference between the delicacy of the meat he eats at different times; but as it is well known that the flavour of meat may be affected by circumſtances that are totally unconnected with the breed, ſuch as, in

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ſome kind of animals, the age at which they have been killed, or the nature of the food upon which they have been fed, or the time the meat has been kept after it has been ſlaughtered; and as no pains is, in general, taken to diſcriminate how far either of theſe circumſtances have tended to operate in the particular caſe in queſtion, each individual feels himſelf, in general, diſpoſed haſtily to conclude, that the particular circumſtance which he chances to have fixed upon as obnoxious, or the reverſe, has occaſioned the good or the bad flavour he perceives. Is his mutton peculiarly delicate —one man immediately concludes, it muſt have been fed upon heath, which gives it the high flavour.—If bad, it has been fed upon turnips; or it is, perhaps, the age— or the ſize—or any other circumſtance that may chance to operate upon his imagination at the time—but he ſeldom thinks of aſcertaining with the neceſſary degree of preciſion, whether this be the fact or not. I myſelf know, for a certainty, that I have heard things of this nature repeatedly mentioned as facts that were inconteſtible, which I knew at the time to be totally different

ferent from what was asserted, when it would have been very idle, or very rude in me to have contested it: neither have I myself had opportunities of ascertaining the fact referrible to this head with the necessary precision to be able to lay down any rules that can be relied upon. My observations go no farther than to furnish me with reasons for doubting; but they have been long enough continued to authorize me to suggest hints for farther investigation. In short, I have seen reason to be satisfied that, independant of age, and food, and every other circumstance which tends to affect the taste of meat, there is a flavour peculiar to the meat of every distinct breed of domestic animals that are reared in this island, which can only be changed by blood. I do not say that this flavour cannot be altered by the circumstances above stated;—far from it—for I know that the alteration that may be produced by these means is always very great. What I mean is simply this; that under the same circumstances respecting age, food, and every other particular, the flavour of the meat of two distinct breeds will be different, in most cases.

In regard to mutton, I ſhall beg leave to ſpecify the true Welſh breed, and the new Leiceſterſhire, as the greateſt contraſt to each other that I know.—The firſt I conceive to be by much the fineſt flavoured mutton I have ſeen, and the laſt the loweſt. —The difference is to me nearly as great as between a golden pippin, and an ordinary apple. Whether this difference of flavour depends upon the breed or the feed, may be aſcertained by very eaſy experiment. Let any gentleman who has a convenient incloſure, buy a ſcore of lambs of one year old, of each kind; let them be turned together into as rich a paſture as you pleaſe, and let the two beſt of each kind be always choſen at the ſame time, when wanted, and then ſlaughtered, and treated in every reſpect alike, till the whole ſhall be conſumed, as they advance in years. Two of the ſame age will thus always be compared together; if no difference in the flavour be then perceived, I am clearly in a miſtake.—Many other good conſequences, beſides that here ſtated, would reſult from this experiment, if conducted with

with accuracy, and faithfully recorded; and it would cost nothing.

I shall just add, that I have reason to suspect that the delicacy of flavour is by no means necessarily connected with the *size* of the breed; for though, in this instance, it should be found that the smallest is preferable, I have no doubt but that in other trials it would be found that the reverse would be the case.

FINIS.